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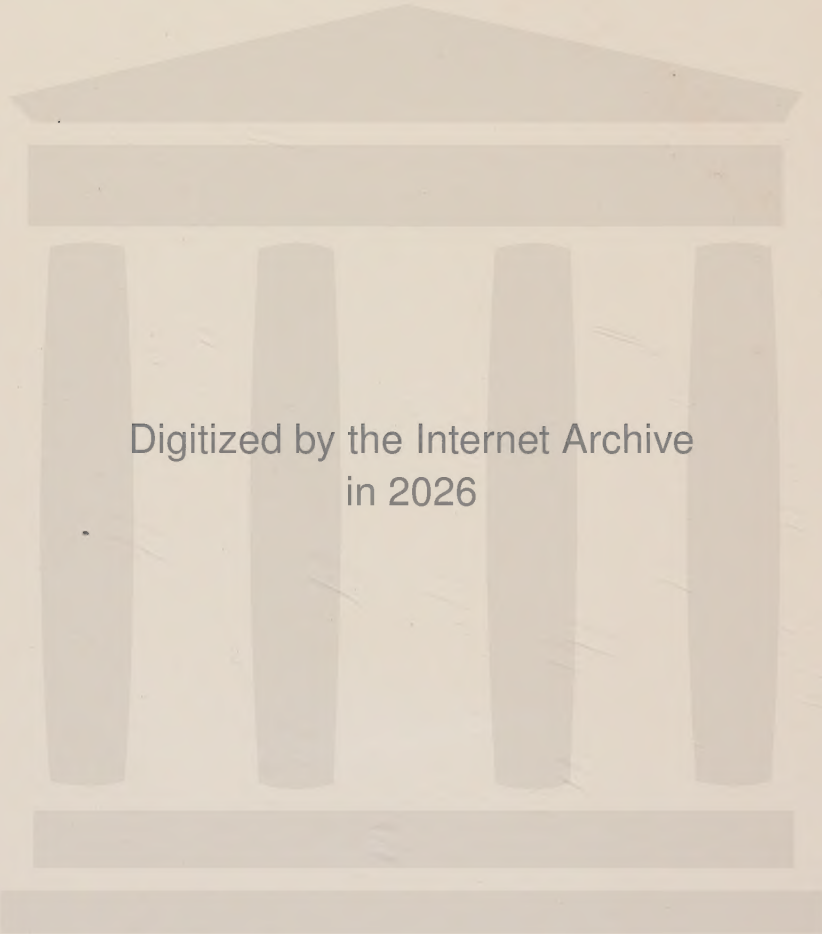
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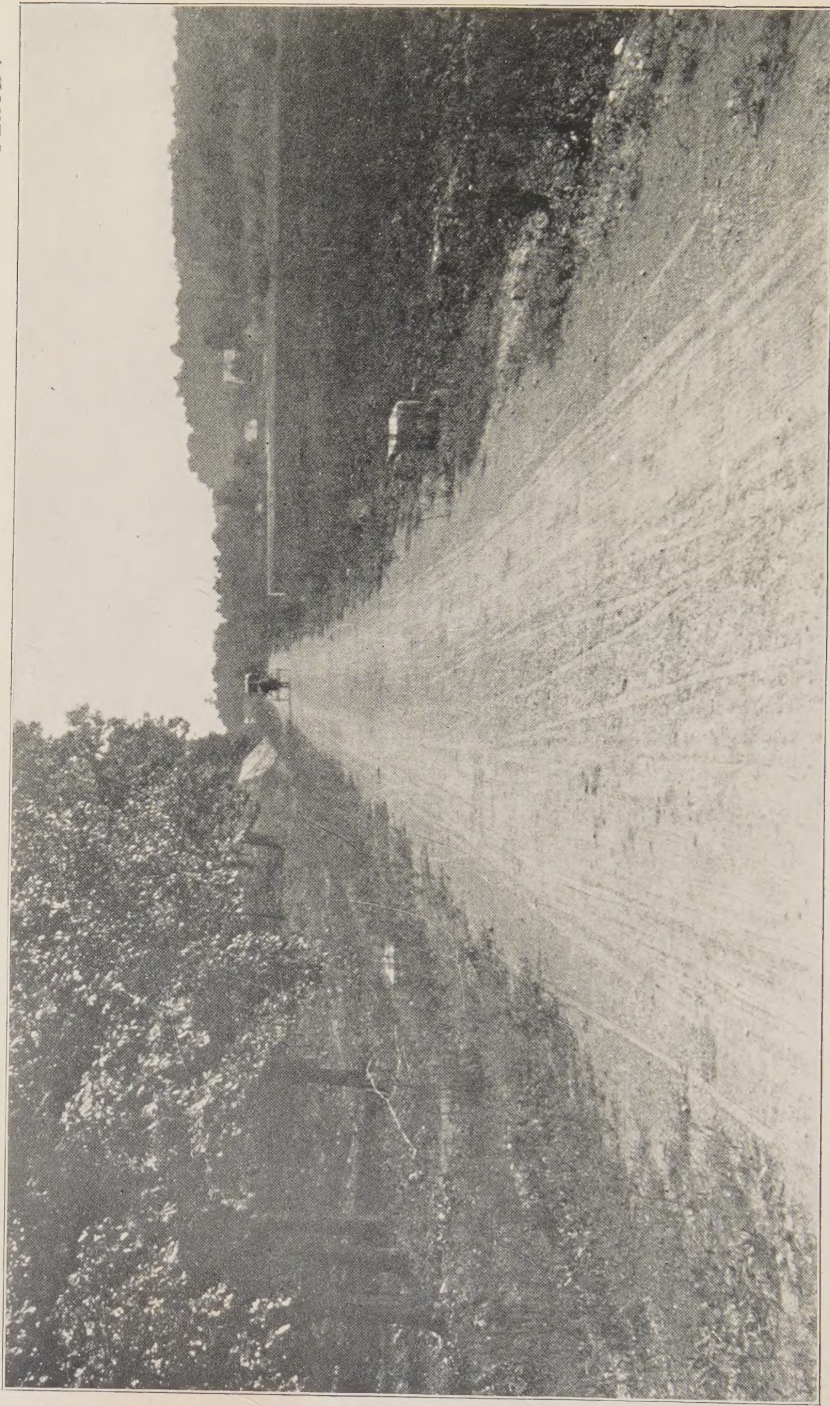
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VIEW OF A UNITED STATES GOVERNMENT ROAD, CHICKAMAUGA PARK, GEORGIA.

GEOLOGICAL SURVEY OF GEORGIA

W. S. YEATES, State Geologist

BULLETIN NO. 8

A PRELIMINARY REPORT

ON THE

ROADS

AND

ROAD-BUILDING MATERIALS

OF

GEORGIA,

BY

S. W. McCALLIE)
Assistant Geologist

1901

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LETTER OF TRANSMITTAL

GEOLOGICAL SURVEY OF GEORGIA,
Atlanta, Feb. 1st, 1901.

*To His Excellency, A. D. CANDLER, Governor and President of
the Advisory Board of the Geological Survey of Georgia,*

SIR:—I have the honor to transmit herewith the report of Mr. S. W. McCallie, Assistant Geologist, on the ROADS AND ROAD-BUILDING MATERIALS OF GEORGIA. This report, which has been ready for the printer, since the fall of 1899, has not been sent to the press, because of lack of funds, with which to publish it, a condition recently relieved by the Legislature in session assembled.

While it is confidently expected, that the report will have great value in encouraging the building of good roads over the State, a thing that would contribute so largely to the wealth of our people; still also it will show to desirable prospective immigrants and others decided advantages in the greatly improved condition of the roads in many parts of the State, especially those sections, contiguous to our principal cities.

Many improvements have been inaugurated since the preparation of this report, which I would, that we were able to include herein; but it would require such extensive work to bring the report to date, that I do not feel justified in withholding it longer from the press.

Very respectfully yours,

W. S. YEATES,
State Geologist.



ROADS AND ROAD-BUILDING MATERIALS OF GEORGIA

CHAPTER I

HISTORY OF ROAD CONSTRUCTION

The evolution of road construction in all countries progresses along certain definite lines, and is very intimately connected with the various stages of civilization. The road of the primitive man, before the use of beasts of burden, was an imperfectly marked pathway through the forest, similar to the trails of gregarious animals. His bridges and causeways were fallen trees or driftwood, nature's own handiwork. As civilization progressed, the more docile animals of the plain and the forest were tamed, and many of them became beasts of burden. This necessitated an improvement in the roadways. The former trails were consequently widened, the more precipitous hills were avoided, and the stones and fallen trees were removed from the pathways. The beast of burden either forded or swam the streams, while his master ferried the freight across on rudely constructed rafts. This stage of road development and method of transportation is now chiefly confined to barbaric and half-civilized nations. Nevertheless, it is also met with in civilized countries, especially in newly settled districts or mountainous regions. Prof. N. S. Shaler, in speaking of this method of transportation, in his excellent book on American Highways, says: ¹ "More than half of the world is still in this 'pack-train' state".

¹ American Highways, by N. S. Shaler; page 2.

Following this stage of development, and brought about mainly by the introduction of wheeled vehicles, the roadways were broadened, the grades were lessened, and the morasses and quagmires were made passable, by the use of broken stones or other unyielding materials. The change from the imperfect foot-paths to the admirable highways of our modern civilization was a gradual, but, at the same time, a natural growth, resulting from the accumulated knowledge of various nations, extending through many centuries.

Rome was the first nation, to attain an advanced stage in highway construction. Many of these excellent Roman roads, such as the Appian Way, were in use, more than three centuries before the beginning of the Christian era. During the prosperous days of the Empire, twenty-nine military roads are said to have radiated from the Imperial City. The total length of these several roads, together with their various branches, aggregated more than 50,000 miles. They were built and maintained at great expense by the general government, primarily, to facilitate the rapid movement of troops from place to place in time of war; and, secondarily, to make trade possible between the various divisions of the Empire. In laying out the national highways, the Roman engineers disregarded grades, and constructed their roads along straight lines, regardless of obstacles. Hills and valleys were, consequently, frequently crossed at great expense, rather than deviate from a direct line to the objective point.

The Roman roadbeds were massive works of masonry, from eight to sixteen feet in width, three or more feet in thickness, and costing probably, on an average, \$50,000 per mile. Austin T. Byrne, in his treatise on Highway Construction, gives the following plan adopted by the Romans, in the construction of these national highways:—

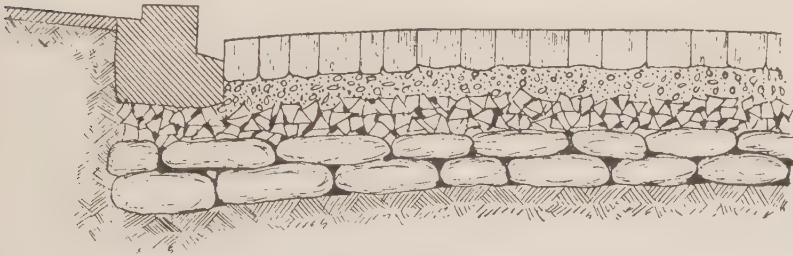
“A trench was excavated the entire length and width of the roadway; in this trench, the road materials were placed, arranged in four layers,¹ having a total thickness of about three feet: (1) the *stratumen* consisting of two courses of large flat stones laid in

¹ See Fig. .

lime-mortar ; (2) the *rudus*, composed of broken stones mixed with one third their quantity of lime, and well consolidated by ramming ; (3) the *nucleus*, a mixture of broken brick, potsherds, tiles and lime ; (4) the *summa crusta*, a pavement of irregularly shaped stones about six inches thick, closely jointed, and fitted with the utmost nicety”.

In time, these several layers became compact, and formed a solid mass, almost as durable as rock itself. Remains of these highways, constructed nearly 2,000 years ago, are still to be seen in Italy and other countries, where they frequently form the founda-

Fig. 1



Cross-section of Roman Stone Pavement (after Byrne).

tion for modern roadways. In a few instances, they are said to form even the surface of roads now in use.

As the Romans extended their dominion into other countries, by conquests, they, at the same time, introduced their system of road-construction, which thereby made free communication between the distant points of the Empire possible. Spain, France, Egypt and also Great Britain, early in the Christian era, were traversed by great Roman thoroughfares. These gigantic national highways, kept up at enormous expense, either by the general or the municipal government, were mostly abandoned after the fall of the Roman Empire. They were looked upon by some of the less enlightened races as means of facilitating invasions by foreign armies ; and, for that reason, they were, in many cases, either destroyed or allowed to go into disuse.

Some writers have given to the ancient Egyptians the credit of reaching an advanced stage in highway-construction, at a very early date. It has been pointed out, with a considerable degree of plausibility, that the huge stones, used in the erection of the pyramids, could have been transported only over specially prepared, unyielding roadways. The character and the extent of these roads, however, if they actually existed, are not known.

The Incas in ancient Peru also constructed extensive roadways at a very early period. Prescott, the historian, in speaking of these roadways, says:—

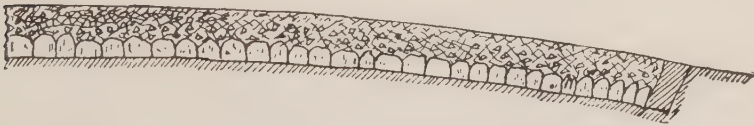
“Galleries were cut for leagues through living rock; rivers were crossed by means of bridges, that swung suspended in the air; precipices were scaled by stairways hewn out of the native bed; ravines of hideous depth were filled up with solid masonry; in short, all the difficulties that beset a wild and mountainous region, and which might appal the most courageous engineer of modern times, were encountered and successfully overcome. The length of the road, of which scattered fragments only remain, is variously estimated at from 1,500 to 2,000 miles. Its breadth scarcely exceeded 20 feet. It was built of heavy flags of freestone, and in some parts, at least, was covered with a bituminous cement, which time has made harder than stone itself”.

Humboldt and DeLeon also give wonderful accounts of the royal Peruvian roads; but some of the modern travelers have not been so fortunate in locating their remains.

After the impulse, which had been given to the betterment of roads in Europe by the Romans, had died away with the decline of that Empire, but little attention seems to have been paid to this class of internal improvement, until the latter part of the 18th Century. It was during this period, that France, mainly under the influence of Napoleon, made great improvements in her highways, by introducing a modern system of road-building. This new plan of road-construction, which was introduced by Tresaguet, a French engineer, in 1764, greatly reduced the cost of road-making, as compared with the method adopted by the Roman engineers.

The principal difference in the change thus brought about consisted in diminishing the number of layers constituting the road-bed,¹ and a corresponding reduction in the total thickness of the material used. Tresaguet's method of construction consisted in the use of only two layers of stones. The lower layer or foundation was made of heavy stones forming a pavement several inches in thickness. Upon this solid foundation, was placed a layer of small broken stones, which constituted the surface of the roadway. There was a marked similarity between the Tresaguet and the Telford road, the chief distinction being the lack of a crown in the foundation of the latter.

Fig. 2



Cross-section of Tresaguet Road (after Byrne).

The great impetus in road improvement, begun in France, soon extended into Great Britain, Germany, Switzerland and other European countries. The highways of Great Britain were in a deplorable condition, as late as the latter part of the 17th Century. Macaulay, the historian, in speaking of the method of transportation in England during this period, says:² "It was only in fine weather, that the whole breadth of the roads was available for vehicles. Often the mud lay deep, on the right and on the left; and only a narrow track of firm ground rose above the quagmire. At such times, obstructions and quarrels were frequent, and the path was sometimes blocked up during a long time by carriers, neither of whom would break the way. It happened almost every day, that coaches stuck fast, until a team of cattle could be procured from some neighboring farm to tug them out of the slough." The same author, in giving an account of a trip of

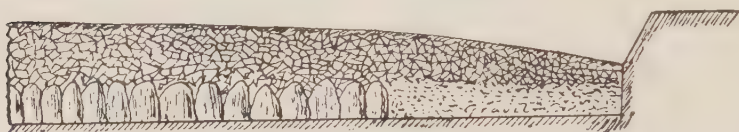
¹ See fig. 2.

² History of England, Vol. I, p. 292.

a viceroy in 1685 into Ireland, says: "Between Conway and Beaumaris, he was forced to walk a great part of the way; and his lady was carried in a litter. His coach was, with great difficulty and by the help of many hands, brought after him entire. In general, carriages were taken to pieces at Conway, and borne on the shoulders of stout Welch peasants to the Menai Strait". This wretched state of the highways is accounted for, in a great measure, by the government's placing the entire burden of road maintenance upon the few inhabitants living along the thoroughfares between the cities and towns.

Shortly after the restoration of Charles II, the clamor against the unjust road burden became so violent among the country-

Fig. 3



Cross-section of Telford Road (after Byrne).

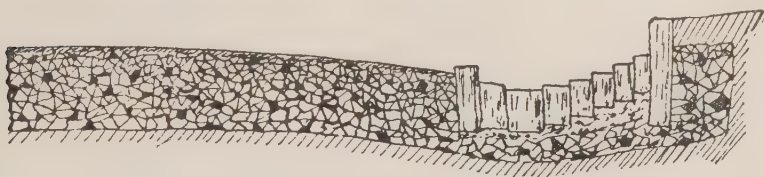
people, that an Act was passed by Parliament, allowing toll-gates to be erected upon certain thoroughfares, in order to collect money for the purpose of keeping these roads in a passable condition. The act, for several years, met with bitter opposition. However, it had great influence in the improvement of the highways, and was the beginning of a movement, which finally culminated during the following century in an excellent system of turnpikes.

The English engineers followed the plan of road-constructing, adopted by Tresaguet, until 1820, when Thomas Telford, an eminent Scotch engineer, introduced a new system, since called the Telford method, from the name of its inventor. The Telford plan of construction,¹ as previously stated, differed but slightly from the Tresaguet method, both being a modified plan of the Roman system. A short time prior to the above named date,

¹ See fig. 3.

John London Macadam, also a Scotch engineer, introduced the present system of macadamized roads. Macadam's plan of road-building¹ differed so widely from all known methods of highway construction, that it was looked upon by the English engineers with general disfavor, until its merits were practically demonstrated in France by the construction of a number of important highways, modeled after that plan. Macadam considered the heavy stone foundation, used by Tresaguet and Telford, not only a useless expenditure of money, but also really harmful to a first-class roadway. His roadbeds were accordingly made entirely of small broken stones, none of which were over two inches in diameter.

Fig. 4



Cross-section of a Macadam Road (after Byrne).

France, Switzerland, Germany, Italy and other European countries have each, in the last century, made remarkable improvements in their highways. The imperfectly kept dirt roads have been transformed, by means of liberal governmental or municipal aid, into magnificently paved ways, the envy and delight of all American travellers.

The improvement of highways in the United States dates from the Colonial times. The advancement, however, during this period, made but little progress. This was due, in a great measure, to two causes, first, the demoralizing effect of the wretched condition of the roads in the mother country; and second, the location of the settlements along the coast,

¹ See fig. 4.

where transportation could be carried on more advantageously by means of boats. As the settlements extended into the interior, roadways were opened up, connecting them with the coast. Many of these ways were first laid out for military purposes; but afterwards they became highways of travel and traffic. They were maintained and kept up, by exacting of the male inhabitants so many days' labor each year, and occasionally, by hired labor, paid for by special taxes collected for that purpose. No paved highways were constructed in the United States, until several years after the close of the Revolutionary War. Washington is said to have been a strong advocate of the improvement of highways; and, during his public life, a number of measures were discussed in Congress, with a view to furnishing federal aid, for the purpose of building government roads. One of the most important outcomes of these several discussions was the passage of an act in 1806 appropriating money to build a national road from the Atlantic seaboard to the interior. This road, after much delay, was ultimately completed from Cumberland, Maryland, westward, through Pennsylvania, West Virginia, Ohio and Indiana, into Illinois, at a total cost of many hundred thousand dollars. It was four rods wide, thirty feet of which, in Maryland, Pennsylvania and West Virginia, was macadamized with broken stone. The road was kept up for some years by the general government; but it was finally turned over to the States, through which it passed.

Ten years previous to the passage of the act mentioned above, the first company in the United States was organized in Pennsylvania, for the purpose of building a turnpike. The road constructed by this company extended from Philadelphia to Lancaster, a distance of seventy miles. The toll-road system, thus introduced, became quite common in the New England, the Middle and a few of the Southern States, in the early part of the present century. A half dozen turnpikes are said, at one time, to have radiated from Boston. They were numerous in New York and Pennsylvania; and, at a later date, they were con-



CHICKAMAUGA LIMESTONE QUARRY, CHICKAMAUGA PARK, GEORGIA.

structed in portions of Kentucky, Tennessee, North Carolina and Georgia. These roads were not always models of highway engineering. Nevertheless, they were a great improvement over the common roads, and served an excellent purpose in impressing upon the people the value of good roadways.

Since the late war between the States, the turnpikes have generally passed into disfavor, and their charters have been revoked. Special taxes are now raised, in the majority of the States, for road purposes; and many influences are being brought to bear, for the improvement of public roads. Probably the greatest stimulant in recent years, in the good-road movement, has been the introduction of the bicycle.

The commencement of road-building in Georgia began with its early colonization. The first roads in the State were laid out in the vicinity of Savannah, under the direction of Oglethorpe. These roadways were afterwards continued through the pine forest to Ebenezer and Fort Argyle; and, later, they were extended along the old Indian trails to the settlements further southward. Probably the oldest road in Georgia, of any importance or extent, is that from Savannah to Darien. This road was surveyed in 1736 by Hugh Mackay, assisted by Augustine and Tolme, and a number of Indian guides furnished by Chief Tomo-chi-chi.

As far as the writer has been able to ascertain, no laws were enacted by the colonists, for laying out and maintaining highways, until 1755. During this year, the General Assembly, in session at Savannah, passed an act, the object of which is set forth in the following preamble:—¹

“Whereas, it is absolutely necessary, that the Public Roads should be made thro’ the Province of Georgia for a speedy communication to the most distant parts of it, and for the ease and convenience of its inhabitants, We, therefore, humbly pray your most Sacred Majesty, that it may be Enacted, and be it Enacted by the Governor, Council and Assembly of the Province of Georgia,

¹ Colonial Acts of Georgia, 1755-1774, p. 63.

and by the Authority of the same, That the surveyors hereinafter named and appointed shall be, and they are hereby impowered, to lay out such High Roads, Private Paths, Bridges, Creeks, Causeways and Water Passages in this Province, and to establish such ferrys, as they shall think proper, for the more direct and better convenience of the Inhabitants of this Province”.

According to the act, the province was divided into nine districts, in each of which were appointed six surveyors, whose duty it was to lay out and keep in repair the highways of their respective districts. In case the work to be performed could not be accomplished by the personal labor of the road hands, who were required to work, if necessity demanded it, as much as twelve days each year, the Surveyors were given the power to assess a tax of all male inhabitants, between the ages of sixteen and sixty, for the accomplishment of the same. The act required all roads to be twenty-four feet wide, and trees to be left on either side, convenient for shade. Cutting down or otherwise injuring any of these shade trees was punishable by a fine of twenty shillings.

After the Revolutionary War, numerous acts were passed by the legislature, from time to time, for the betterment of the highways. Many of these acts were of a local nature, applicable only to certain districts and to frontier times. In the newly settled counties, for instance, the following clause was generally inserted in all highway enactments: “Every road hand shall carry with him one good and efficient gun or pair of pistols, and at least nine cartridges to fit the same, or twelve loads of powder and ball or buck shot, under a penalty of one dollar, for every day he shall neglect so to do”. There were also numerous plans devised, from time to time, to raise money to improve certain important highways. One of the first schemes of this nature was instigated in 1802, in order to obtain means to construct a road from Savannah to New-Deptford. The parties having the building of the road under consideration were empowered, by a special enactment, to raise by lottery 10,000 dollars to carry out the work. Other plans, of a less objectionable character, were resorted to, in order to raise

money for road improvement ; but none of them seem to have met with the general approval of the masses ; and, as a result, the highways in the early part of the present century were kept up almost entirely as at present, by the labor of the road hands of the rural districts.

The national government, during the first settlement of Georgia, contributed, from time to time, several thousand dollars for the purpose of opening up roads in different parts of the State. Some of these roads are still in use, and are frequently spoken of as the old federal roads.

In 1829, there was considerable interest manifested throughout the State in the improvement of roads and rivers. During the latter part of this year, an act was passed by the General Assembly appropriating \$70,000 for the purchase of negroes to be used in improving the highways and navigable streams. About 200 slaves were thus procured by the State and placed in charge of two superintendents appointed by the Governor. The duty of the superintendent was to direct and oversee all improvements and make annual reports to the General Assembly, describing the nature of the work performed and the cost of the same. The improvements inaugurated under this enactment began under very favorable auspices, and the necessary appropriations were willingly voted, from year to year, to carry on the work. In a short time, however, dissensions arose. It was claimed, that the works were poorly managed ; and furthermore, that a few localities only were being benefited at the expense of the entire State. Influences were accordingly brought to bear upon the Legislature, and the appropriation was discontinued, after the expenditure of about \$200,000. The superintendents reported about 200 miles of road built, mostly in the vicinity of Columbus, Macon, Milledgeville and Augusta, during the time, that the law was in force.

Hardly had the above plan of road improvement passed into disfavor, when there was much interest shown in highway improvement throughout the State by the building of turnpikes. Between 1834 and 1850, the General Assembly incorporated no less than

twenty-five companies for the purpose of building such roads. The majority of these charters were for roads to be constructed in the northern part of the State, where the mountainous nature of the country rendered the building and the maintenance of roads especially expensive. Various schemes were adopted to secure money to build the turnpikes, the most common being the selling of stock, the instituting of lotteries, and the application to the legislature for State aid. In a few instances, the State granted small sums for such improvement; but, in the majority of cases, the turnpikes were opened and kept in a passable condition by stock companies. Some of these roads were made of planks; but, as a general rule, they consisted of the common dirt roads, kept in a fair condition for travel by the employment of hired labor.

With only one or two exceptions, the charters for turnpikes expired or were recalled before the late war; and no effort has since been made to revive the system of toll-roads. The turnpike system of highway improvement established no first-class roads of a permanent nature in the State. Nevertheless, it had its influence in educating the people to a point, where they were more willing to tax themselves for the betterment of highways.

In the last twenty-five years, there has been no marked or very sudden change toward the betterment of the public roads of the State; yet, during this time, there has been a gradual, growing sentiment in that direction.

One of the most effective means brought about in recent years, looking to the improvement of highways, has been the adoption of the so-called new road law. This law, inaugurated in 1891, authorized the commissioners of roads and revenues of each county, upon the recommendation of the grand jury, to fix and levy a special road-tax, not to exceed 2 mills on the dollar; and also to exact of each male inhabitant a commutation-tax, not to exceed 50 cents per day for the number of days, work is required. Furthermore, the law authorized these road authorities to organize chaingangs of misdemeanor convicts, or to hire free labor for the improvement and the maintenance of the highways, the expenses

being met by the special road and commutation taxes. About one-fifth of the counties of the State have since adopted this new road law, and are now keeping up and improving their highways, either by hired or convict labor. This system meets with general approval, wherever it has been tried, and it is now only a question of time, when it will be universally adopted throughout the State.

The usual method adopted in this system of road-working is as follows: Convicts or free laborers are organized into squads, consisting of fifteen to forty-five men, which are placed under a competent superintendent and one or more overseers. Each squad is furnished with a camping outfit, two or more road-machines, wheeled scrapers, wagons, from ten to twenty mules, plows, etc. The work usually commences on the leading roads, radiating from the county-seat, and consists, first, in going over the road with machines, giving them the proper crown, opening up the side ditches, macadamizing the boggy places, and occasionally cutting down the grades of the steeper hills. The main highways being thus worked over, attention is then directed to the less important roads, until all the highways in the county have been crowned and properly drained. This first working usually requires from one to two years, depending upon the condition of the roads and the number of hands employed. The second time the roads are gone over, more attention is paid to grading, and considerable macadamizing is frequently done, and the work in general is of a more permanent and lasting nature.

It is the intention of the road managers adopting this plan to keep up this process of gradual road improvement, until all the principal thoroughfares, at least, in their respective counties are properly graded, macadamized, and otherwise put in first-class condition. Such, in brief, is a condensed outline of the method of working the roads in the counties, where only a small force of laborers is maintained. In those counties having large cities, as Fulton, Chatham, Richmond, Bibb and Floyd, where from 100 to 400 convicts are employed, the roads are frequently graded and macadamized at the first working, and are afterwards kept in

repair by a small force of hands detailed for that purpose. Under this system of road-working, several hundred miles of first-class macadamized or gravel roads have been built in the various counties of the State, within the last three or four years. Some of these roads, such as the Manchester or the Peachtree roads in the vicinity of Atlanta, are ideal thoroughfares, and are the envy and delight of all visiting wheelmen. Other roads, of similar merits, are found in the counties of Richmond, Chatham, Bibb, Floyd etc. The people in these counties are thoroughly in sympathy with the good-road movement, and frequently refer with pride to the excellent condition and constant improvement of their highways.



CHAPTER II

THE VALUE OF GOOD ROADS

The value of good roads can hardly be overestimated. It would indeed be a difficult matter to mention any of the various products of human industry, which are not directly or indirectly affected by the condition of the highways. If the cost of a commodity be analyzed, it will be found, that a considerable percentage of its value is due to transportation. The food we eat, the clothing we wear, together with all the other necessities of life, with few exceptions, are each subject to this universal taxation.

The cost of transportation depends mainly upon two factors, namely, the time and the force required to move a commodity from one place to another. If the time is short and the force is small, the cost of transportation will be reduced to a minimum; but, if the time is long and the force is great, then the cost of transportation will reach a maximum. Both these elements of cost are dependent, to a great extent, on the state of the public roadways; and, as a consequence, any improvement in their condition will affect, to a greater or less extent, the cost of all commodities, whose value depends upon transportation, and, at the same time, increase the profits of the producer and cheapen the cost of living to the consumer.

The advantage of highway improvement may be considered, as suggested by Prof. W. C. Latta, under the following heads:—

1 *Good roads lessen the time and force, in transportation to and from the market.*

2 *Good roads enable the products and the farm supplies to be delivered, at all seasons of the year.*

3 *Good roads diminish the wear and tear on vehicles, harness and horses.*

4 *Good roads increase the value of real estate.*

GOOD ROADS LESSEN THE TIME AND FORCE IN TRANSPORTING PRODUCTS TO AND FROM MARKET. — Other things being equal, the time required to carry a given load a certain distance depends upon the character of the roadbed. If the roadbed is smooth and devoid of grades, the maximum speed can be attained and the objective point reached in the shortest possible time.

The question of economizing time is often of vital importance to the farmer. Especially is this true, when the products of the farm are of a perishable nature. Rapid transit enables the producer, not only to transport his perishable products long distances without the risk of loss; but it also makes it practicable for him to meet the demands of an ever fluctuating market and to obtain the highest price for his products. The total loss, annually sustained by the farmers of the United States, on account of their not being able to market their perishable products in due time, is enormous. That this statement is not overdrawn is evident, if we take into consideration the immense amount of vegetables, fruits etc., which are continually allowed to waste and decay, on account of the time consumed in their transportation. Nor is the loss, due to this cause, confined to the perishable products alone. Often, it falls with equal weight upon the non-perishable products. It is estimated, that the farmers of the United States lost last year¹ on the wheat crop alone several million dollars, on account of their not being able to get it to market at the proper time.

That good roads greatly reduce the force, necessary to transport products to and from market, is shown in the table below by Mr. Rudolph Herring, published in the *Engineering Record* some years ago.² The table gives the power, or tractive force, required to move a load of 2,240 pounds, at the rate of three miles per hour, over the various classes of roads.

¹ 1898.

² Condensed from Highway Construction, by Austin T. Byrne, p. 294.

THE ROADS AND ROAD-BUILDING MATERIALS OF GEORGIA

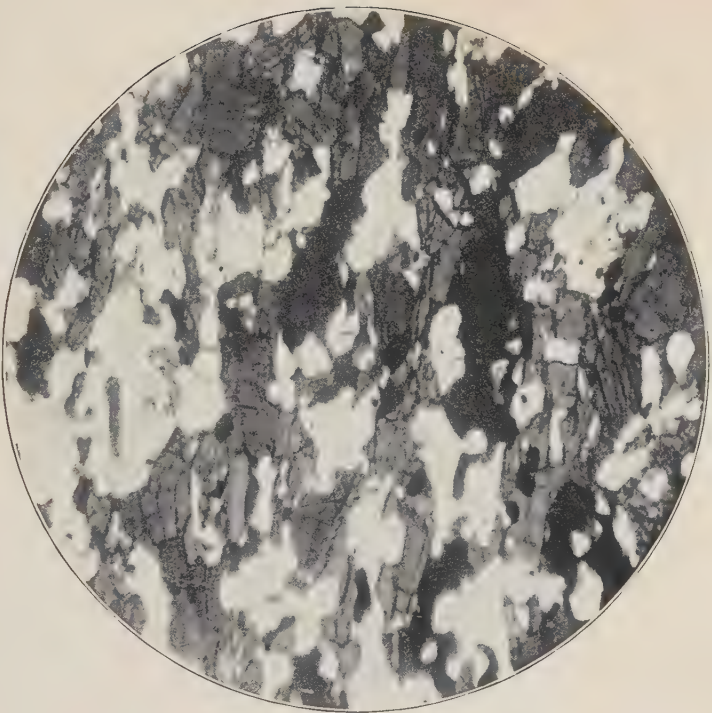


PHOTO-MICROGRAPH OF QUARTZ-DIORITE, FROM A CUT ON THE
ADAMSVILLE ROAD IN FULTON COUNTY, 6 MILES SOUTH-
WEST OF ATLANTA. IN ORDINARY LIGHT X 75.

PLATE III

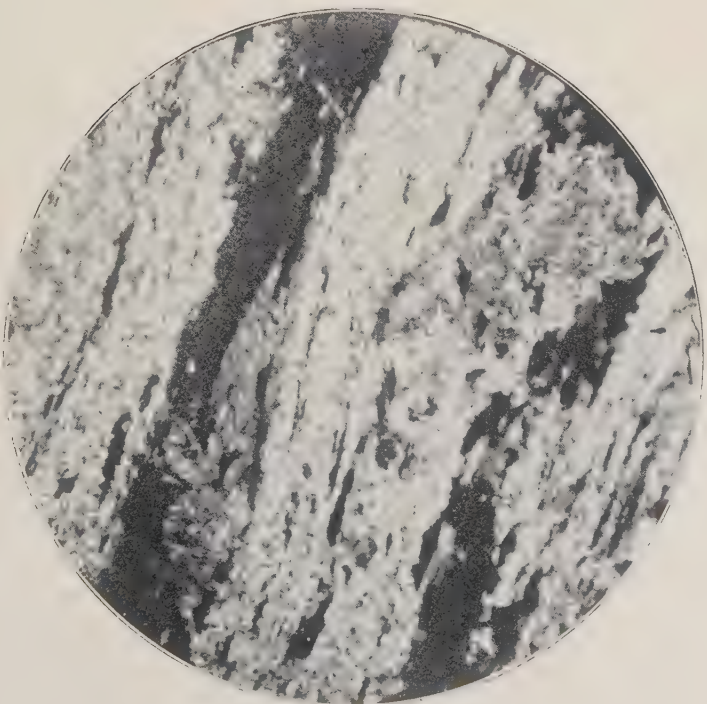


PHOTO-MICROGRAPH OF MICA-SCHIST, FROM A DEEP WELL
BORING, NEAR AUSTELL, GEORGIA.
BETWEEN CROSSED NICOLS X 75.

EFFECT OF DIFFERENT SURFACES ON THE TRACTIVE FORCE

TABLE NO. I		Tractive Force	
Kind of Road			
Loose sand		448	lbs.
Loose gravel (deep)		320	"
" " (4 inches)		222	"
Common gravel road		147	"
Good gravel		88	"
Hard road gravel		75	"
Ordinary dirt road		224	"
Hard clay		112	"
Hard, dry dirt road		89	"
Macadam (little used)	140 to	97	"
Bad macadam		160	"
Poor macadam		112	"
Common macadam		64	"
Good macadam (wet)	75 to	42	"
Best French macadam		45	"
Very hard and smooth macadam		46	"
Best macadam	52 to	32	"
" "		50	"
Cobblestone (ordinary)		140	"
" (good)		75	"
Belgian blocks		56	"
" " in Paris	54 to	34	"
" "		37½	"
" " (good)		34½	"
" "	50 to	26	"
Stone block (ordinary)		90	"
" " (good)		45	"
" " (London)		36	"
Asphalt		17	"
Granite tramway		13½	"
" "		12½	"
Iron railway		11½	"
" "		8	"

Mr. Austin T. Byrne, in discussing the tractive power of an average horse in good condition, says:¹ "The average tractive

¹ Highway Construction, by Austin T. Byrne, p. 301.

force of a horse on a level, and actively pulling ten hours, may be assumed approximately as follows :—

TRACTIVE POWER OF HORSES AT DIFFERENT VELOCITIES

TABLE NO. 2

Miles per Hour	Tractive Force	Miles per Hour	Tractive Force
$\frac{3}{4}$	333.33 lbs.	$2\frac{1}{4}$	111.11 lbs.
1	250.00 "	$2\frac{1}{2}$	100.00 "
$1\frac{1}{4}$	200.00 "	$2\frac{3}{4}$	90.91 "
$1\frac{1}{2}$	166.66 "	3	83.33 "
$1\frac{3}{4}$	142.86 "	$3\frac{1}{2}$	71.43 "
2	125.00 "	4	62.50 "

These estimates are based on practical tests made upon level roads. Where the roadbed inclines, forming a grade however small, the tractive force required to move the same load must be rapidly increased as is shown by the following table :—¹

EFFECT OF INCLINATION

Table No. 3 gives the tractive force necessary to draw 1 ton over the best macadam road of various grades and the equivalent length of each mile of grade in miles of level road.

TABLE NO. 3

Rate of Inclination	Angle with the Level	Tractive Force	Equivalent Length of Level Road in Miles
	° ' "	Pounds	
Level.....	0 00 00	38	1.00
1 in 500.....	0 06 53	42	1.10
1 in 100.....	0 34 23	58	1.52
1 in 80.....	0 42 58	63	1.66
1 in 60.....	0 57 18	71	1.87
1 in 50.....	1 08 16	78	2.05
1 in 40.....	1 25 57	88	2.30
1 in 30.....	1 54 37	104	2.73
1 in 25.....	2 17 26	118	3.10
1 in 20.....	2 51 21	138	3.63
1 in 15.....	3 48 51	171	4.50
1 in 10.....	5 42 58	238	6.26

¹ Bulletin No. 20, U. S. Dept. of Agri., Office of Road Inquiry, p. 21.

By comparing tables 1 and 2, it will be observed, that a horse having a speed of three miles per hour can exert, for ten consecutive hours, a pulling force of 83.33 pounds, which is equivalent approximately to moving 2,240 pounds 30 miles over a good gravel road, or twice that amount (4,480 pounds), the same distance over the best macadamized road. Furthermore, if table 3 is taken into consideration in the comparison, it will be seen, that the horse can move 2,240 pounds over a road having a grade 1 to 10 only about 5 miles or $\frac{1}{6}$ of the original distance. In the last comparison, the grade considered is unusually high, the maximum in first-class roads being 1 to 30. However, it must be borne in mind, that the road under consideration in table 3 is the best quality of macadamized road. If the comparison were made with our average Georgia dirt road during the early spring, the grade might be reduced to zero, and still the horse could not accomplish the above work in the given time. In other words, a load of 2,240 pounds, 10 miles, or what is its equivalent, 1,120 pounds 20 miles, is more than an average day's work for a horse on the common public roads of Georgia. That this statement is not overdrawn, is shown in circular No. 19 by Gen. Roy Stone, Director of the Office of Road Inquiry, U. S. Department of Agriculture. As this information was obtained from the replies to ten thousand letters, sent to intelligent and reliable farmers throughout the country, it is supposed to be reasonably reliable, and can be depended upon, as approximately correct. The average 2-horse load, therein given for the Cotton States, is 1,397 pounds a load, greater by only 277 pounds than the above estimated load for one horse. In view of this statement, it is obvious, that the work assigned to one horse, namely, 1,120 pounds, 20 miles in 10 hours, is actually more than the average horse will really accomplish on the common public roads of Georgia. However, in order to show the enormous cost of bad roads to the State, and, at the same time, have a wide margin for error, these figures will be used in the discussion.

Again referring to tables 1 and 2, it will be seen, that one horse can move a load of 4,480 pounds 30 miles over a first-class mac-

adamized road, in 10 hours; or two horses can move twice that load (8,960 pounds) the same distance in the same time; whereas, the above estimate for a 2-horse load on the average Georgia road is only a fourth of that amount (2,240 pounds), 20 miles. But suppose, that the 2-horse team could actually go thirty miles on the average Georgia dirt road with 2,240 pounds, in 10 hours. Even then, the same team could haul four times the load, with the same exertion, over a first-class macadamized road, such as now exists between Atlanta and Manchester, in the same time. In other words, if the State of Georgia had first-class macadamized roads, only a fourth of the draft horses now engaged in transportation would be necessary to accomplish the work; or, what is the same thing, all the traffic of our public roads could be carried on at an expense of only a fourth of its present cost. The aggregate amount, thus annually lost to the citizens of the State, is evidently a very large sum, as is shown by the following statement. According to the above cited circular, by Gen. Stone, the average cost per ton for the whole length of haul, for farm products in the Southern States, is \$3.05. At this rate, it costs the farmers of Georgia, in round numbers, \$3,000,000 to market their cotton and deliver their fertilizers. As good roads would reduce this sum by three-fourths, the saving to the farmers of the State on these two articles alone would aggregate more than \$2,250,000. To this sum, we might reasonably add \$1,000,000 more, three-fourths of the haulage charges on all other products. This would give a grand total of \$3,250,000, the amount annually lost to the farmers, chargeable to overdraft due to bad roads.

GOOD ROADS ENABLE THE FARM PRODUCTS TO BE MARKETED, AND SUPPLIES TO BE DELIVERED AT ALL SEASONS OF THE YEAR.—It is a well known fact, that, in the winter and early spring months, the majority of our common dirt roads become well-nigh impassable for heavy traffic. During this season of the year, the teams, which might be profitably engaged in hauling the farm products to market, remain idle, at a considerable expense to their owners in the matter of attention, feed etc. Prof. J. A.

Holmes, State Geologist of North Carolina, in discussing this item of expense chargeable to bad roads, places the loss due to this cause in 56 middle and western counties of that State at \$1,600,000 per annum, an amount sufficient to build more than 75 miles of first-class macadamized road. Prof. Holmes's line of argument in supporting the above statement is as follows:¹ "These 134,000 country horses and mules, credited to the middle and western counties, cannot be used during four weeks of the year on account of bad roads. The cost of feeding them per day, at twenty cents each, is \$26,800, which for the four weeks amounts to \$750,400. Now, let us add to this the item of the loss of time for these animals. Putting this at twenty-five cents per day (twenty-four days), we see another source of loss, amounting to \$804,000. These two items give us a total of \$1,554,400 per annum, which may be charged against the impassable public roads. Let us add to this the cost of the following items, which will amount in the aggregate to certainly not less than \$50,000: (1) Value of the services of ox-teams and the cost of finding them, during the four weeks; (2) and the loss farmers sustain by not being able to carry farm produce, tobacco, cotton etc., to markets at times when prices are highest; and the result presents at a reasonable estimate, a total loss of more than \$1,600,000 per annum, to be charged against excessively bad public roads in North Carolina, during these four weeks."

Now, if the above figures are correct, and they are undoubtedly plausible, it would be no exaggeration to say, that the farmers of Georgia annually sustain a loss of more than \$2,000,000 from this cause alone. In other words, this large sum of money would be an annual net gain to the farmers of the State, if the roads were so improved, that teams could be used at all seasons of the year. Furthermore, besides the pecuniary loss, we should also take into consideration the effect of bad roads upon the social condition of the country. During the winter and early spring, bad roads are responsible, in a great measure, for the poor attend-

¹ North Carolina Geological Survey, Bulletin No. 4, Road Materials and Road Construction in North Carolina, p. 33.

ance on the public schools, the closing of churches, and a cessation of all social and friendly intercourse in the rural districts. To this cause, also, a recent writer attributes the unusual influx of young men from the farm into our cities, and the resulting gorged and over-crowded conditions of the other trades and professions.

GOOD ROADS DIMINISH THE WEAR AND TEAR ON VEHICLES, HARNESS AND HORSES. — It is probably impossible to give any definite estimate, as to the actual cost of the wear on vehicles, harness and horses due to bad roads. However, the loss due to this cause must amount, in the aggregate, to many thousand dollars, annually. This is evident, if we take into consideration the dilapidated vehicles, the broken harness and the jaded and strained condition of the horses throughout the State, which is chargeable, in a great measure, to the impassable condition of the public roads. In an adjoining State, it is said, that the number of black-smith and harness-shops have been greatly reduced in the country, since the introduction of macadamized roads, and also, that there is a marked change noticeable in the condition of the draft-horses now to be seen on the highways. One author, in discussing this item of cost, due to bad roads, expresses the opinion, that the usefulness of all vehicles, harness and even draft-horses would be prolonged at least one third, if all highways were kept in first-class condition. This statement is probably overdrawn. However, suppose the annual loss to be only \$10.00 per team; even then, the aggregate loss to the State per annum would amount to more than \$500,000.

GOOD ROADS INCREASE THE VALUE OF REAL ESTATE. — No means of increasing the value of the real estate of a commonwealth, is probably so effective as the improvement of its highways. Mr. Clarence Coleman, in discussing the effect of good roads upon the value of real estate, before the Virginia Good Roads Convention at Richmond, in 1894, said:¹ "It is stated upon good authority, that in Union county, N. J., by reason of the im-

¹ Bulletin No. 11, U. S. Dept. of Agri., Office of Road Inquiry, p. 19.

proved system of road construction and maintenance, farming lands are estimated at an average of \$206 per acre, as against the average value of \$65 per acre for the other part of the State." In the same convention, Rev. Dr. Ray stated,¹ that the lands on the eastern shore of Virginia had increased in value, from \$10 to \$100 per acre, in the last few years, chiefly on account of the improvement of the highways. The writer has in mind a farm, in one of the Eastern States, which, a short time ago, was offered for sale at \$20,000. Since the completion of a first-class macadamized road through the farm, the owner has refused an offer of \$30,000 for the property. Prof. W. C. Latta, of Purdue University, places the estimated average increase of valuation per acre, that would result, if all common roads were improved, at \$9.00. Other instances might be indefinitely enumerated, showing large increases in the values of real estate, brought about, in a great measure, by the improvement of the highways. However, it is not necessary to assume such large gains as the above, to show, that the increase in value of real estate in any commonwealth, due to the betterment of public roads, must aggregate an immense sum. Let us suppose, that the construction of good public roads throughout the State of Georgia would increase the value of our lands \$2.00 per acre. This estimate is certainly not overrated, as every person will testify, who has experienced the beneficial effect of good roads. Nevertheless, this insignificant amount, as it may appear to the general reader, would aggregate more than \$70,000,000, a sum equal to about a half of the present assessed valuation of all the farming lands of the State. Such an amount of money is ample, not only to grade and macadamize all our leading public roads, but also to pay the entire State debt, with a sufficient surplus remaining, to bear the expense of running the State Government for a number of years. Granting an increased value of only \$1.00 per acre, on a belt of land one mile in width on each side of a road; even then the aggregate increase in the value of such a narrow strip of land

¹ Bulletin No. 11, U. S. Dept. of Agri., Office of Road Inquiry, p. 19.

alone would be sufficient to build a first-class road in any part of the State. That is, any section of the State can construct good roads, by levying a tax of \$1.00 per acre, on all lands lying within one mile of the proposed road.

Leaving out of consideration entirely the increased value of real estate and summing up the foregoing estimates, we have a total aggregate of \$6,250,000 annually, chargeable to the bad roads of Georgia. This amount is sufficient, to construct 3,000 miles of macadamized road, and is nearly twice the annual assessed State taxes.



THE ROADS AND ROAD-BUILDING MATERIALS OF GEORGIA



PHOTO-MICROGRAPH OF OLIVINE-DIABASE, FROM A DIKE ON
THE SOUTHERN RAILWAY, 2 MILES SOUTHWEST OF
GAINESVILLE, GEORGIA.
BETWEEN CROSSED NICOLS X 75.

PLATE IV



PHOTO-MICROGRAPH OF OLIVINE-DIABASE, 5 MILES NORTH OF
MACON, GEORGIA.
BETWEEN CROSSED NICOLS X 75.

CHAPTER III

ROAD CONSTRUCTION

LOCATION OF ROADS.—The Roman engineers, in constructing the imperial roads, as has been previously noted, are said to have always laid them out, in straight lines from one objective point to another, regardless of intervening obstacles. Modern highway engineers no longer follow the rule, adopted by the Romans; but, on the contrary, other things being equal, they always locate the roads along the lines of easy gradient. Gen. Q. A. Gillmore, in discussing the question of road location, says:¹ “The considerations, which should govern the engineer in locating the line of ordinary wagon-roads, are (1) the present and prospective amount of traffic over the road; (2) its general character, whether light or heavy; (3) the convenience and necessities of the community tributary to the line; and (4) the natural features of the country through which the road must pass.” Taking these several conditions into consideration, it is at once evident, that the location of a road really involves a rather complex economic problem. If the question of grades is alone taken into consideration, the convenience of the road is likely to be sacrificed, to a greater or less extent; and, at the same time, the cost of maintenance is materially increased. On the other hand, if convenience is considered, the grades may become so great, as to render the road practically impassable for heavy traffic.

Mr. Austin T. Byrne, in his treatise on highway-construction, lays down the following general principles, to be observed in locating highways:—²

¹ Roads, Streets and Pavements, p. 9.

² Highway Construction, by Austin T. Byrne, p. 316.

- “1 Follow the route, which affords the easiest grades. The easiest grade for a given road will depend upon the kind of covering adopted for its surface.
- 2 Connect the places by the shortest and most direct routes commensurate with easy grades.
- 3 Avoid all unnecessary ascents and descents. When a road is encumbered with useless ascents, the useless expenditure of power is considerable.
- 4 Give the center line of the road such a position with reference to the natural surface of the ground, that the cost of construction shall be reduced to the smallest possible amount.
- 5 Cross all obstacles, where structures are necessary, as nearly as possible at right-angles.
- 6 Cross ridges through the lowest passes.
- 7 Cross either under or over railroads. Grade crossings are always dangerous to the users of the highway, and, if possible, should be avoided.”

It will be seen from the above principles, that the first thing to be done in the location of a road is to study the topography of the section through which the road is to pass. Where topographic maps of the region have already been made out, they can be used to a great advantage in locating the most practical line for the proposed road. When these are not accessible, there must be a preliminary survey made, showing the location and trend of the streams, hills and ridges, together with the relative positions of the objective points, to be reached by the road. Having obtained this desired information, the highway engineer proceeds to definitely locate the line of road, which will best accommodate the traffic, for which it is to be constructed. The easiest grades, the shortest distances, and the smallest rise and fall consistent with the cost of construction, all receive due consideration from the faithful engineer, before the line of road is permanently located.

It may be noted, as a common rule, in mountainous or hilly countries, that the best and most important highways, like railroads, are located along streams or ridges. Each of these locations has its disadvantages. Ridge-roads are often dry and destitute of running water, so that both man and beast are frequently compelled to travel long distances, without water to relieve their thirst. Furthermore, the descent of these roads to the valleys below are likely to present difficult problems to the engineer, in securing a practical grade. The location of roads along valleys, on the other

hand, is frequently objectionable, on account of the extra expense of keeping up bridges. Even if the line of road does not cross the main stream of the valley, there are always many small tributaries or deep gorges to be bridged.

The problem, now presented to the advocates of good roads in the South, is not so much a question of locating new roads, as it is of changing the location of roads already in existence. This is especially true of the State of Georgia, where many of the roads were originally laid out along lot-lines or division boundaries between properties, regardless of the various obstacles encountered. These mistakes must be corrected, in a great measure, before it will be possible to construct first-class roads, of easy grade, throughout the State, at anything like a reasonable cost. Road Commissioners should by all means see, that their roads are always properly located before attempting any permanent improvement. It would probably be no exaggeration to say, that many of the leading highways in this State would require an expenditure of several thousand dollars per mile, in grading alone, to put them in first-class condition for heavy traffic. Such conditions as these are practically prohibitive of good roads, until they shall be re-located. Changing the location of established roads frequently presents a simple problem to the engineer; but, at the same time, it may save hundreds of dollars per mile in the cost of construction.

GRADES.—By the term grade, as used in highway construction, is meant the degree of inclination from the horizontal, or the slope of the surface. When not designated by degrees, the grade is expressed either in the form of a simple ratio, as, for example, 1 : 20, or by the percentage amount. The ratio 1:20 indicates a rise of 1 foot in every 20 feet, or a 5 per cent. grade.

The grade of a road should depend, in a great measure, upon the character of the traffic, for which the road is to be used. If the traffic is heavy, and the individual loads are necessarily large, it is always advisable to reduce the grade to the lowest possible minimum consistent with the cost of construction. Most highway engineers place the maximum grade of macadamized roads at

1 to 30. Such maximum grades, however, should be as short as possible; as they overstrain the team, and render frequent stops necessary, to relieve the animals from fatigue. By reference to table No. 3, page 26, it will be seen, that the tractive force, required to move a given load over a road, with a grade of 1 to 30, is nearly three times as great, as that, required to move the same load over a level road. The maximum load for any team should always be governed by the maximum grade to be overcome. A short grade of 1 to 30, at any point on an otherwise level road, will reduce the efficiency of a team nearly one-third, and at the same time increase the cost of transportation in the same ratio. It is nearly always practicable to reduce the grade of a road to the above maximum limit, even in mountainous regions, by

Fig. 5



Cross-section of a Macadam Road (after Shaler).

making the line of road sinuous or zig-zag. This principle of highway-construction is admirably illustrated at many of our Southern mountain resorts, where roads, of easy grade, reach, in a short distance, elevations of many hundred feet above the valleys below. Besides reducing the efficiency of tractive force, steep grades also greatly augment the cost of keeping roads in repair. Every observant person has noticed, how difficult it is to keep a hillside road from forming ruts or gullies, on account of the erosive action of running water. The erosive power of water varies, as the square of its velocity; so it is obvious, that a slight increase in grade will greatly increase the effective force of this destructive agent. A practical highway engineer, in discussing the question of grades, has said, that the extra expense, incurred in maintaining a road with high grades, will frequently in a short time aggregate a sum sufficient to pay the entire expense of re-locating the road.

DRAINAGE.—There is no problem, presented to the political road-builder, of more importance than drainage. Unless a road is properly drained, it is practically impossible to keep it in first-class condition. Water must be removed from the roadway, or it will rapidly destroy the compactness of the surface, and sooner or later render the road impassable. This is true, not only of common dirt roads, but of macadamized roads as well.

The drainage of roadways is naturally divided into two divisions, namely, surface drainage and subdrainage. The object of surface drainage is to conduct the water, which falls on the surface of the road, into the side ditches or drainways, as quickly as possible, while the subdrainage removes it from beneath the surface.

Fig. 6



Cross-section of a Macadam Road.

Surface drainage is accomplished, mainly by giving the surface of the roadway a slight inclination from its centre to its sides. This is called “crowning” the road. Engineers differ as to the shape of the crown of roads. Some contend, that it should be a convex curve, approximately circular; and others advocate two uniformly sloping planes at the sides, connected in the middle of the road by a small circular arc.¹

The angle of the slope, which the crown of the road should have, depends, in a great measure, upon the character of the material used in forming the surface. When the material is easily permeated, the angle of slope should be greater than for impermeable material. The usual grade for the crown of a macadamized road is about 1 in 30. That is, a roadway, 60 feet in width, should be one foot higher at the center than at the sides. The crown of a dirt road should be somewhat greater; but in no instance should

¹ See figs. 5 and 6.

it be so great as to confine the traffic to its center, by reason of the sloping conditions of its sides, or to cause an undue erosion of the surface from heavy rains. The water, as it flows from the surface of the roadway, should be received in properly constructed drains, on either side of the road.¹ These drains should have suf-

Fig. 7



Cross-section of Earth Road Showing Side-Drains.

ficient slope to conduct the water off, as rapidly as it accumulates, into the cross channels or culverts. Frequently, a road properly crowned and supplied with suitable side ditches needs no further drainage. In many cases, however, subdrainage is also necessary, to secure the desired results. The object of subdrainage is not only to remove the water, which may penetrate the surface from above, but also to draw off the water which, by lateral seepage, enters the roadbed from below.

Fig. 8



Cross-section of a Macadamized Road Showing Central Sub-drain and Side-drains.

Subdrainage is accomplished by the use of either side or central drains.² Side-drains may be open or closed, and should always have a depth of $2\frac{1}{2}$ to 3 feet below the surface of the roadway, with sufficient slope to carry off the water. Open drains perform the double office of carrying off both the surface and the underground waters; and, for this reason, they are often preferable to closed drains. These drains, however, on account of their

¹ See fig. 7.

² See figs. 8 and 9.

depth and their proximity to the roadway, are frequently dangerous. Gen. Gillmore meets this objection by suggesting, that open under-drain ditches be placed on the field side of fences or hedges in the agricultural districts, where accidents to vehicles are most likely to occur. The width of an open drain and the slope of its

Fig. 9

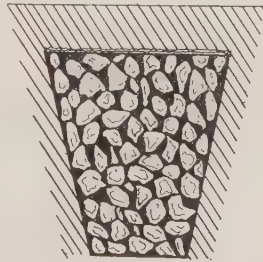


Cross-section of a Macadamized Road Showing Lateral Sub-drains.

sides should be governed by the amount of water to be carried off, and by the character of the soil. If the soil is sandy or friable, the sides of the ditch should slope at a low angle; otherwise, they will cave and soon render the ditch practically useless for drainage purposes.

Closed drains are variously constructed. One of the simplest, and, at the same time, most cheaply constructed closed drains is shown in fig. 10. It consists of a narrow, properly-graded ditch, about three feet in depth, and partly filled with stones. In constructing a drain of this character, it is always advisable to use rounded stones, placing the largest on the bottom and the smallest on the top. Such an arrangement gives ample space at the bottom for the free circulation of the water, and prevents the washing in of the earth from above. To guard more completely against the filling of the spaces between the stones by earth, it is often best to overlay them with grass or straw before filling the upper part of the ditch with earth. There are several modifications of

Fig. 10



Cross-section of a Blind Drain (after Spalding).

this plan of stone drain differing mainly in the arrangement of the lower layers of the stones.¹ Where stones are not to be had, a drain can be made of logs, poles and brush, which will answer

all practical purposes. The following description of such a drain is given by Mr. Charles W. Irish in Bulletin No. 8, published by the U. S. Office of Road Inquiry :—

“The materials used are a few waste logs and some brush, of any kind handy, and some poles for covering the brush.² Supposing the trench *e, f, g, h* is 3 feet wide on the bottom, *f, g*. I put in, at the sides of it, two logs, *a, a*, each about 8 or 10 inches in diameter. Between

these logs, I place brush, laid criss-cross, and thoroughly rammed and tramped into place, filling up the space to a height of 3 or 4 inches above the logs. On the top of the small bush, so rammed into place, I lay poles about 3 or 4 inches in diameter, one or two courses deep, and then fill in the trench to the top with earth well rammed.”

A drain, constructed after this manner, was found by Mr. Irish to be in good condition after a use of twenty years.

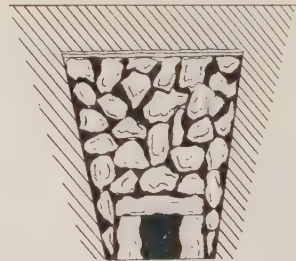
The most durable and satisfactory material for use in the construction of underground drains are bricks and tiles. The different methods of using bricks for underground drainage is shown in figs 14, 15, 16 and 17, taken from Gillmore.³ In order to make this method of drainage as effective as possible, it is

Fig. 11



Cross-section of a Stone Drain.

Fig. 12



Cross-section of a Stone Drain.

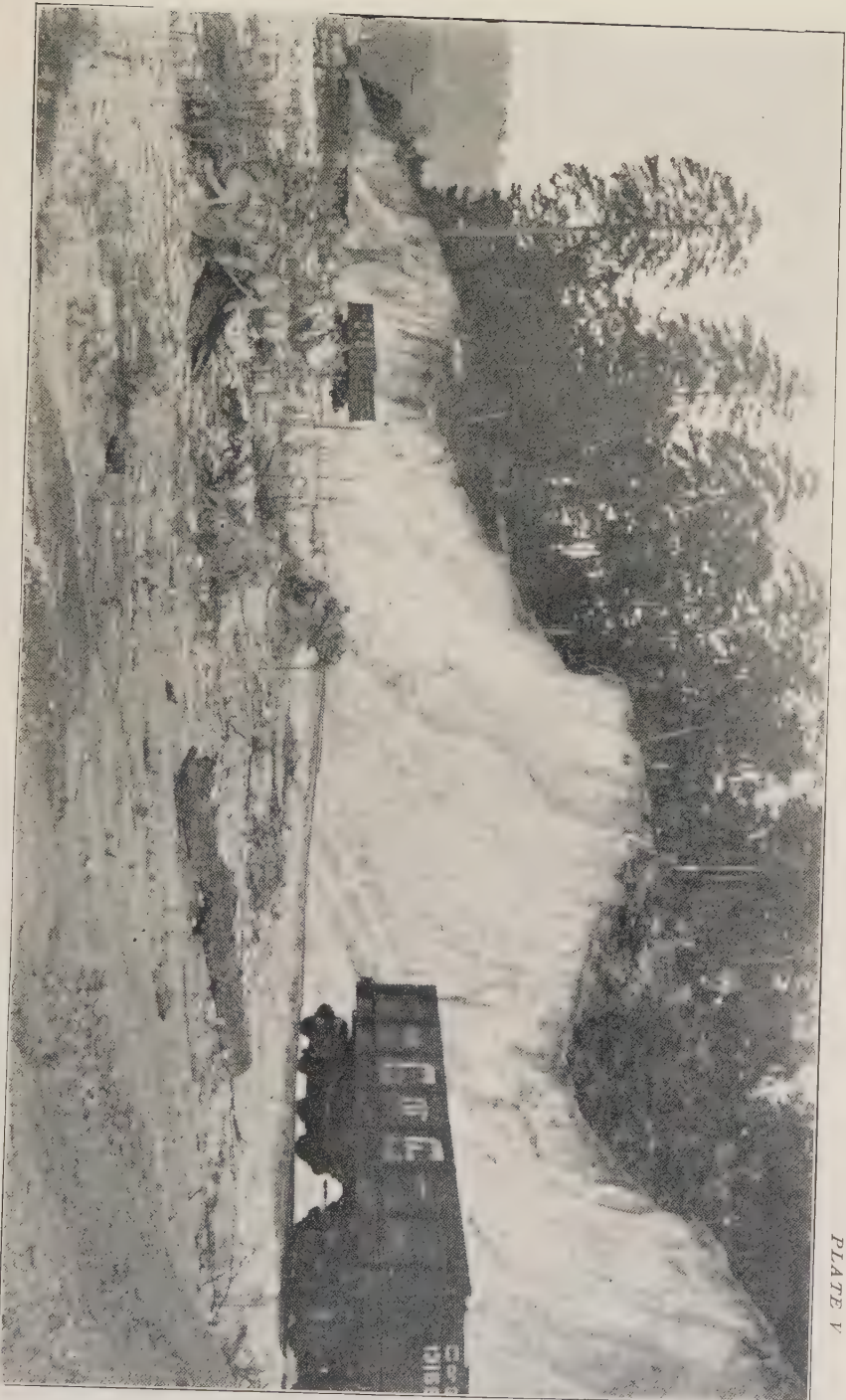
¹ See figs. 11 and 12.

² See fig. 13.

³ Roads, Streets and Pavements, by Q. A. Gillmore, p. 56.

THE ROADS AND ROAD-BUILDING MATERIALS OF GEORGIA

PLATE V

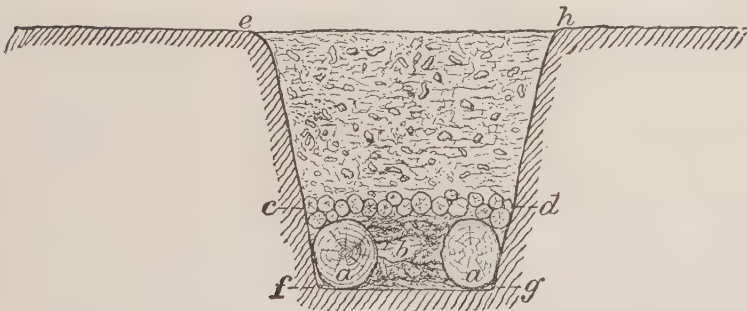


A CHERT QUARRY NEAR SUMMERVILLE, CHATTOOGA COUNTY, GEORGIA.

essential, that the lower part of the ditch be filled with stones, gravel or coarse sand, so as to allow the water an easy access to the opening below. Drains properly constructed of brick will last for an indefinite period and always give satisfactory results.

Tile-drains are probably the best and most effective of all underground drains. The form of the tile, employed in under-draining, is usually round, and varies in diameter from 3 to 6 inches, according to the amount of water to be carried off. The tiles should be evenly laid, and have a slope of about 1 foot in 100, insuring an

Fig. 13



Cross-section of a Brush Drain. *e-f-g-h*, the Trench. *a-a*, Logs, 10 inches in Diameter. *b*, Brush. *c-d*, Poles, 2-4 inches in Diameter.

effective flow. The ditch, in which the tiles are placed, should be partially filled with stones,¹ as in the case of brick-drains.

The cost of tile-drains is said to be less than either stone or brick-drains. Mr. Henry F. French, in discussing the cost of drains, says: "Drainage with tiles will generally cost less than one-half the expense of drainage with stone, and will be incomparably more satisfactory in the end." The following price-list of tiles suitable for underground drainage is taken from Mr. Isaac B. Potter's excellent booklet on Macadam Roads:—

¹ See fig. 18.

PRICE-LIST OF HARD BURNED DRAIN-TILE

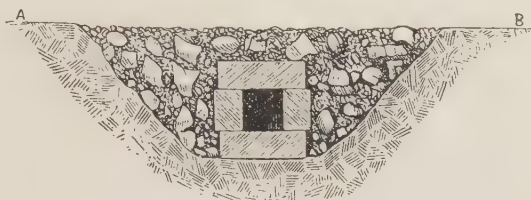
Size	Area in Inches	Weight per Foot	Price per 1,000 Feet	Curves and Reducers, Each	1 Foot Branches, Each	2 Foot Branches, Each	No. Feet to Car Load
2 inch . .	3.141	3	\$ 20.00	\$ 0.20	\$ 0.30	. .	8,000
3 inch . .	7.068	4½	30.00	.20	.30	. .	6,000
4 inch . .	12.566	6½	45.00	.25	.30	. .	4,000
5 inch . .	19.625	9	60.00	.30	.40	\$ 0.50	3,000
6 inch . .	28.274	12	80.00	.40	.50	.70	2,200
7 inch . .	38.484	15	110.00	.50	.70	.75	2,000
8 inch . .	50.265	22	150.00	.70	.75	.90	1,250
9 inch . .	63.617	26	200.00	.75	1.00	1.00	1,000
10 inch . .	78.539	33	250.00	1.00	. .	1.15	850
12 inch . .	113.090	44	325.00	1.25	. .	1.25	750
15 inch . .	176.710	60	450.00	1.50	. .	2.00	500
18 inch . .	254.460	92	700.00	2.25	. .	2.50	350
20 inch . .	314.160	106	1,000.00	3.00	. .	4.00	250
21 inch . .	345.000	110	1,250.00	4.00	. .	5.00	225
24 inch . .	452.390	150	1,625.00	5.00	. .	6.50	200

Central drains made of stone, brick or tile, are often used by highway engineers for subdrainage, in the place of lateral drains. The material employed, and the method of constructing such drains, are similar to that adopted in closed side-drains. Cross-drains are also, in many cases, found to be essential, in order to secure satisfactory drainage of a roadway. These are closed drains, made of stone, brick or tile, and connected with the side or central drain, into which they deliver the water. Cross-drains on a grade should be in the form of a V, with the apex directed toward the ascent.

Besides the above-named drains, there is another important class of waterways in common use in road construction. These drains are called culverts, and are often waterways of considerable size. The object of culverts is to conduct under the roadway the water, which collects from the side-ditches; also, to furnish a free passage to the smaller streams intersecting the road. It is usually best, especially in building first-class macadamized roads, to construct

the culverts of stone or brick. Good examples of such waterways, and the plan of their construction, may be seen and studied in all railroad culverts. Where the amount of water to be conducted beneath the roadway is limited, large-size drain-tiles answer all purposes, and can be put in place at a small cost. Wooden culverts soon undergo decay; and for this reason, they should never be used in permanent first-class highways.

Fig. 14



Cross-section of a Drain.

ROAD SURFACES

Having graded and properly under-drained the roadway, the next process in highway building is to construct a suitable surface, over which the traffic is to pass. This is accomplished in all first-class highways, by covering the specially prepared road-bed, to the depth of several inches, with broken stones, or some other unyielding material. Numerous methods are adopted by highway engineers in constructing hardened surfaces for roadways. One of the oldest methods, to be generally adopted by practical road-builders, and one, that is still in common use, is the Telford method.¹

The Telford Road.—The Telford plan of road construction, as previously stated, was invented and introduced by Telford in 1820; and it is best described in his own specifications:² “Upon

¹ See fig. 3.

² Roads, Streets and Pavements, by Q. A. Gillmore.

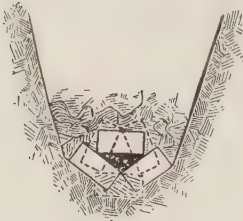
Fig. 15



Cross-section of a Drain.

a level bed, prepared for the road materials, a *bottom course or layer of stones* is to be set by hand, in the form of a close, firm pavement. The stones, set in the middle of the road, are to be seven inches in depth; at nine feet from the center, five

Fig. 16



Cross-section of a Drain.

inches; at twelve from the center, four inches; and at fifteen feet, three inches. They are to be set on their *broadest edges and lengthwise across the road*, and the breadth of the upper edge is not to exceed four inches in any case. All the irregularities of the upper part of the said pavement are to be broken off by the hammer, and all the interstices are to be filled with stone chips, firmly wedged or packed by hand with a light

hammer, so that, when the whole pavement is finished, there shall be a convexity of four inches in the breadth of fifteen feet from the center.

"The middle eighteen feet of pavement is to be coated with hard stones to the depth of six inches. Four of these six inches are to be first put on and worked in, by carriages and horses, care being taken to rake in the ruts, until the surface becomes firm and consolidated, after which the remaining two inches are to be put on. The whole of this stone is to be broken into pieces as nearly cubical as possible, so that the largest piece, in its longest dimensions, may pass through a ring of two inches and a half inside diameter.

Fig. 17



Cross-section of a Drain.

"The paved spaces on each side of the eighteen middle feet, are to be coated with broken stones, or well cleansed strong gravel, up to the foot-path or other boundary of the road, so as to make the whole convexity of the road six inches from the center to the

sides of it. The whole of the materials are to be covered with a binding of an inch and a half in depth of good gravel, free from clay or earth.'

The modern method of constructing Telford roads differs slightly from the above specifications. It is now customary for engineers in constructing roads of this class, to crown the surface of the roadbed, before the stone pavement is put into place; and also to use sand as binding material for the upper layers of broken stone.

The merits and demerits of the Telford system of road-building is discussed at considerable length, in nearly all works on highway construction. Some of the principal objections urged against the system are as follows:—

1 The pavement foundation forms a permeable layer allowing the water from above to enter and saturate the soil below, so that the rocks subside and the soil rises; and thus the continuity of the surface is finally destroyed.

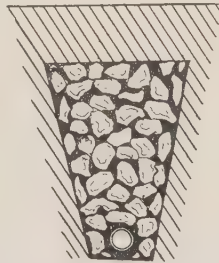
2 The foundation of larger stones makes a hard, unyielding surface like an anvil, upon which the smaller stones above are easily crushed by the impact of the horses' feet.

3 The pavement foundation is expensive, on account of the large amount of stones used in its structure, and the cost of putting them in position.

The advocates of the Telford road meet these objections with many plausible arguments, and, at the same time, bring forward proof in support of this system over all others. Summing up the various arguments for and against the Telford system of constructing roads, the most plausible conclusion seems to be as follows:—

Telford roads should be used, where the roadbed is unstable and difficult to drain; also, when suitable material is not at hand, with which to construct the entire hardened surface. In the latter

Fig. 18



Cross-section of a Tile Drain.

case, inferior stone, such as sandstone etc., can be used in the foundation. Under such conditions, Telford roads can often be most economically constructed.

Macadam Roads.—The Macadam method of constructing hardened road surfaces, which differs from the Telford method mainly in its foundation, is now most generally adopted by highway engineers. This method seems to be well-suited for country roads, from a standpoint both of economy and durability. The specifications, as originally laid down by Macadam, in constructing the Bristol and Bath roads, England, may be summarized as follows: The roadbed, after being properly graded and crowned, was covered, to the depth of 10 or 12 inches, with broken stones, none of which exceeded two inches in their greatest diameters. No binding material whatever was used. Splints, thin slices and dust of all kinds were carefully separated from the stone, before it was put in place on the prepared roadbed. Traffic alone, in course of time, caused this layer of angular stones to form a compact, hard surface, quite free from both mud and dust, and well suited for travel of all kinds.

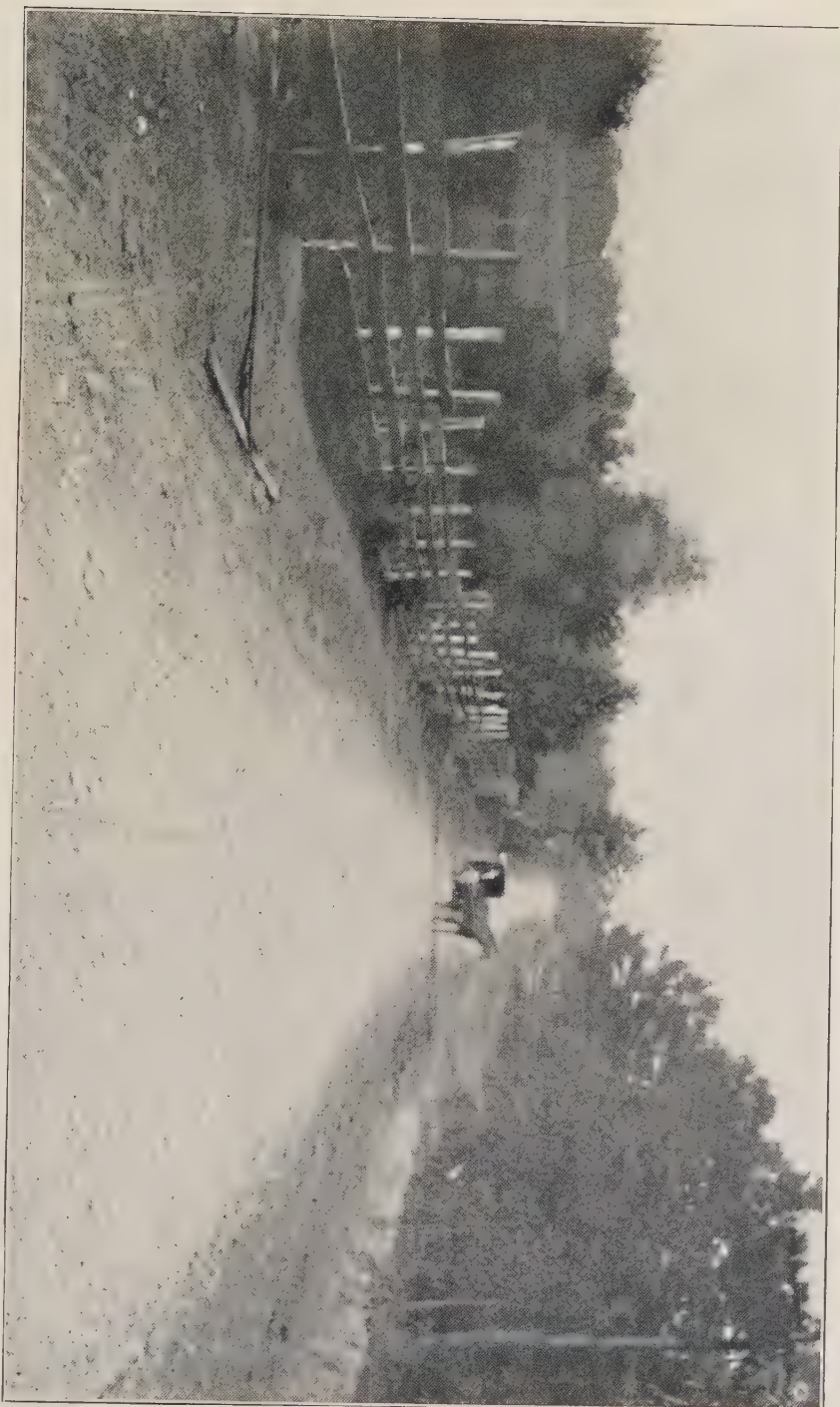
Practical road-builders of the present day, in constructing macadamized roads, as in the case of the Telford road, depart somewhat from the original plans adopted by the inventor. It is now no longer considered essential, in making roads of this character, to free the broken stones from dust and thin chips; but, on the contrary, these materials are regarded as necessary, to fill the interstices, and to bind the broken stones together into a hardened surface. That this modern plan of constructing macadamized roads is based upon a sound theory, is shown by a practical experiment carried on some years ago in New York City by W. H. Grant, Superintending Engineer of Central Park. Mr. Grant, in discussing the system of road-building carried on in the park, says: "At the commencement of the Macadam roads, the experiment was tried of rolling and compacting the stone by a strict adherence to Macadam's theory—that of carefully excluding all dirt and foreign material from the stones, and trusting to

the action of the roller and the travel of teams to accomplish the work of consolidation. The bottom layer of stone was sufficiently compacted in this way to form and retain, under the action of the rollers, an even and regular surface, but the top layer—with the use of the heavy roller loaded to its greatest capacity—it was found impracticable to solidify, and reduce to such a surface as would prevent the stones from loosening and being displaced by the action of the wagon wheels and horses' feet. No amount of rolling was sufficient to produce a thorough binding effect upon the stones, or to cause such a mechanical union and adjustment of their sides and angles together as to enable them mutually to assist each other in resisting displacement. The rolling was persisted in, with the roller adjusted to different weights, up to the maximum load, 12 tons, until it was apparent, that the opposite effect from that intended was being produced. The stones became rounded by the excessive attrition, they were subjected to, their more angular parts wearing away, and the weaker and smaller ones being crushed. The experiment was not pushed beyond this point. It was conclusively shown, that broken stones of the ordinary size, and of the very best quality for wear and durability, with the greatest care and attention to all the necessary conditions of rolling and compression, would not consolidate in the effectual manner required for the surface of a road, while entirely isolated from, and independent of, other substance. The utmost efforts to compress and solidify them, while in this condition, after a certain limit had been reached, were unavailing."

Foreign materials, in many cases, are not only necessary for binding the broken stones together into a hardened mass; but they are also essential, to make the road-covering impervious to the water, which falls on the surface. Broken stones alone are the most permeable of all road materials; and, in place of allowing the water to be speedily carried to the side ditches, they retain it; and this thereby readily softens the foundation, and causes the surface of the roadway to become disintegrated, in a short time. It frequently happens, that the unscreened stone, as it

comes from the crusher, contains sufficient fine chips and dust to bind the angular stones together into a compact, hardened mass. When such is not the case, sand, or some other foreign material, should be added. Some road-builders place the binding material on the surface alone; while others mix it with the entire mass of broken stones forming the roadbed. Each of these methods has its advocates; but a combination of the two, in most cases, would probably be more serviceable; as it would insure a complete bond throughout the entire road-covering.

In constructing a modern macadamized road, it is customary to prepare the roadbed by first giving it the proper grade and crown, after which the roller, or traffic, is passed over it, until the surface is thoroughly consolidated and hardened. The object of the last named precaution is to prevent the lower layer of stones from being pressed into the soil, and thus becoming useless in supporting the layers of stone above. If the soil, on which the broken stones are placed, is of a sandy nature, it is often found almost impossible to secure, even by continuous rolling, or by traffic, a compact, hardened road surface, on account of the intermingling of the sand and broken stones. In such cases, a thin layer of straw, or some other material, should be placed over the surface, before the stone is put in position. The Chief Engineer of the Massachusetts Highway Commission overcame this difficulty, by covering the surface of the sandy roadbed with cheese-cloth. It is said, that the stones, when placed on this cloth, behaved, under the roller, just as if it were on a hard clay foundation, and were easily consolidated into an even compact surface. The cost of this material (about \$700 per mile) will probably, in most cases, prohibit its use. Nevertheless, it well illustrates the fact, that this difficulty may be easily overcome, by covering the sandy surface with a thin layer of some comparatively fragile material. Another object in view in having a compact surface, on which to place the broken stones, is to prevent the water, that may percolate through the road-covering, from entering the foundation clay, and rendering it unstable. The surface of a sub-grade, when properly compacted, becomes, in a great measure, impervious, and speedily conducts the water, which may



A VIEW ON THE KINGSTON ROAD, FLOYD COUNTY, GEORGIA, $3\frac{1}{2}$ MILES FROM ROME, SHOWING MACADAM RECENTLY PUT DOWN.

collect from above, to the side ditches, before it has time to enter and soften the soil.

The surface of the sub-grade, having been prepared as above described, is then ready to receive its covering of broken stones. This material may be prepared, either by hand or by the crusher. Some engineers prefer the former method ; while others prefer the latter. It is claimed by the advocates of the hand-broken stones, that they contain fewer incipient cracks and are less liable to go to pieces under traffic. It is questionable, whether or not this statement can be verified by actual tests ; and, if it can be, it is probably not of sufficient importance, from an economic standpoint, to make it of any pecuniary interest to the practical road-builder. When the amount of stone to be broken is limited and labor is cheap, it is economy in the majority of cases to have the work done by hand ; but, on the other hand, when the quantity of stone to be used is large and the cost of labor is high, it would probably be economy to use the crushed stone.

In constructing first-class macadamized roads, it is always best to place the broken stone on the prepared sub-grade surface, in two or more layers, in order that it may be more completely consolidated by traffic or by the use of the roller. The total thickness of these layers should depend both on the character of the traffic, for which the road is constructed, and, to some extent also, upon the nature of the road foundation. If the traffic is heavy and the individual loads are large, the thickness of the road-covering should be greater than when the opposite conditions exist. Furthermore, even when the traffic is light, the road-covering should be increased in thickness, wherever the foundation is unstable or insufficiently drained.

The French engineers, on their most important highways, make the macadam ten inches thick ; but, on the less important roads, six, seven or eight inches is considered sufficient. In this country, the road-covering varies from 4 to 12 inches, an average being about seven inches. There are said to be excellent macadamized roads in the vicinity of Bridgeport, Connecticut, having a road-

surface of only four inches in thickness. Such thin road-coverings are not, however, advisable, unless the material is exceptionally good and the roadbed thoroughly drained.

The lower layer of stones should be spread as evenly as possible over the prepared roadbed, to the depth of three or four inches; and it should be thoroughly compacted by rolling or by traffic. When the latter method is used in compacting the stone into a solid bed, great care must be taken, to see, that the ruts are filled by broken stones as soon as they are formed. It is always desirable to have the stones as nearly cubical as possible; and, in no case, should they exceed two and a half inches in their greatest diameter. The more cubical the stones, other things being equal, the easier they are to become consolidated into a compact mass. Some road-engineers screen the stone, taking only the larger size for the foundation; while others apply the stone just as it comes from the crusher, with the larger stones, small fragments and dust all combined. The last named method is usually adopted, when a very compact and well-bonded foundation is desired; but, generally, the stone is screened and the small fragments and dust are used on the surface as a binder.

The lower layer of stone having been compressed from about six inches to four inches, it is ready for the reception of the second layer. This layer of stone, in first-class roads, is usually, when consolidated, about three inches in thickness, and consists of fragments one and a half inches, and less, in diameter. As the layer constitutes the actual wearing surface of the road, it is essential, that the stone used should be as hard and tough as possible. The same care should be taken with this layer as with the first, in seeing that it is well compacted and hardened by means either of traffic or the roller.

The road-covering is finally completed, by placing on the surface a layer of binding material, a half inch or more in thickness, which is sprinkled and continuously rolled, until it becomes thoroughly consolidated. One of the best and most satisfactory materials to use as a binder is the chips and dust obtained by screening the broken stones. When such material is not at hand, small

gravel, sand or loam will answer the purpose ; but, in no instance, should clay be used for top-dressing. The object of the thin superficial layer is to form an impervious covering for the roadbed, and, at the same time, to unite the fragments of stone into a perfect bond. Prof. Shaler, in speaking of this superficial covering, says : — ¹

“A coating of ‘fines’ or fragments from the crusher up to half an inch in diameter, is to be spread to the depth of about half an inch. The roller is then to be passed over this last layer, with the result that the bits will be ground to powder. At this stage the road is to be sprinkled with a watering-cart, but one with fine apertures in the pipes, the work being done in several passages. The roller is then again to traverse the way until in its movement the water is forced upward or pushes before the drums of the machine.”

Having constructed the roadbed as above described, and given to its surface a sufficient crown to conduct the water quickly into the gutters or side ditches, we have an excellent country-road, and one, if kept in proper repair, that will last for many years, even under heavy traffic. Such roads are but little affected by the seasons ; and they are as serviceable for traffic in winter as in summer.

The following table shows the cubic yards of broken stone, required per mile of road : — ²

Depth of Stone in Inches	WIDTH OF MACADAM ROADWAY IN FEET							
	8	16	24	30	32	40	48	60
4	645	1,290	1,935	2,421	2,580	3,225	3,870	4,842
6	968	1,935	2,903	3,632	3,872	4,840	5,808	7,264
8	1,290	2,580	3,870	4,842	5,160	6,450	7,740	9,684
10	1,613	3,225	4,838	6,053	6,452	8,065	9,678	12,106
12	1,935	3,870	5,805	7,263	7,740	9,675	11,610	14,526
14	2,258	4,515	6,773	8,474	9,032	11,290	13,548	16,948
16	2,580	5,160	7,740	9,684	10,320	12,900	15,480	19,368

¹ American Highways, p. 157.

² Macadamized Roads, by Isaac B. Potter, p. 57.

Gravel Roads. — Gravel roads are highly recommended by many highway constructors, on account of their cheapness. The gravel used for this purpose may be divided into the two classes, round pebbles and angular pebbles. The rounded pebbles have resulted from the action of water. They are found, in the greatest abundance, along old coast lines, or occupying the beds of former streams. The angular pebbles, on the other hand, are the result of a peculiar disintegration of the parent rock, and frequently occur, in considerable beds, mixed more or less with clay. The water-worn pebbles are usually quartz, or some other hard rock well suited for wear on a road-surface. Intermingled, invariably, with the rounded pebbles, in the natural bed, is to be found either sand or clay filling the interstices and forming a matrix, which binds the materials together. The value of the gravel as a road material depends, to a great extent, upon the nature and physical condition of this matrix. If the matrix consists of sand alone, no amount of rolling or traffic will suffice to compact the material into a hardened road-covering; but, if, on the contrary, the matrix is made up of a sandy clay, with considerable iron oxide, the material is readily consolidated, and forms an excellent road-surface. A fair idea of the binding quality of the matrix of a gravel-bed can usually be obtained, from an examination of the gravel-pit. When the walls of the pit stand perpendicular, for any length of time, without signs of disintegration from freezing or other physical cause, the material will be found, in most cases, to give satisfactory results on the roadway.¹ Water-worn pebbles are extremely difficult to bind into a hard surface, even when the binding material is of the best quality. This is due to the individual pebbles having no mechanical hold on each other; and as a result the compactness of the road-covering must necessarily depend mainly on the binding strength of the matrix. To overcome this physical difficulty as much as possible, it is always advisable to break the large stones before they are placed on the roadway; and also, to use a limited amount of sandy clay, as a binder.

¹ See Plate VIII.

Angular, or what is usually called pit gravel, binds readily into a compact mass; and, on this account, it is commonly preferred to water-worn gravel. This kind of gravel always contains a considerable amount of clay, which should be separated from it by screening, before it is put on the road. It is, furthermore, desirable, in order to obtain a uniform and smooth surface, to remove all the stones having a greater diameter than $2\frac{1}{2}$ inches. When it is not convenient to screen the gravel, the larger stones may be readily removed with a rake, as they are distributed over the surface of the road. Before the gravel is placed in position, the road-bed should be properly prepared by giving it the necessary crown and by compacting its surface, either by the roller or by traffic. The thickness of the gravel forming the road-covering should be greater than for broken stones. Gen. Gillmore says, they should have a total thickness of 10 or 12 inches, and should be put on the prepared road-surface in two or more layers, each layer being thoroughly rolled before the succeeding layer is placed in position. Spalding, in his text-book on Roads and Pavements, in speaking of similar roads, says,¹ that with proper drainage three or four inches of gravel, or even less, will frequently give very satisfactory results. Such roads, however, would not withstand heavy traffic and would be suitable only for pleasure drives or light hauling.

One of the strongest arguments in favor of gravel roads is the cheapness of construction. If the gravel has to be transported only a short distance, this kind of road-covering is unquestionably the most economical of all materials, and is especially well suited for the construction of common country-roads, where the amount of traffic is not unusually heavy. Even under the last named condition, if the gravel covering is ten or twelve inches thick and well bonded by sandy clay and oxide of iron, it will be equal in wearing qualities to the macadam road, unless the material of the latter is trap or some other very tough and durable stone.

¹ A Text-Book on Roads and Pavements, p. 76.

Corduroy Roads.—Corduroy roads are made of small logs or poles, placed side by side across the roadway. They are usually constructed in swampy districts, where drainage is difficult and timber abundant. These roads are used to a considerable extent in South Georgia by lumbermen. They form an excellent substitute for the more costly roadways. One of the main objections to be urged against these roads is the unevenness of the surface. This difficulty, however, can be overcome, in a great measure, by a careful selection of the poles, and by seeing, that they are so adjusted to each other as to leave the least possible space between them. When the poles used are several inches in diameter, it is often advisable to fill the space between them with poles of smaller size split in quarters. If, upon a roadbed thus prepared, a thin layer of brush be placed, or, what is better still, a layer of crushed sugar-cane stalks, and the whole, covered to the depth of two or three inches with earth, the surface will become comparatively smooth, and will form a pleasant roadway. It is always well, before putting the logs in position, to elevate the roadbed a few inches above the maximum water-level of the swamp. This precaution is usually necessary, in order to give the drainage required for a dry surface; and also, to prevent the logs from becoming loosened by the passage of heavy loads. The earth taken from the side ditches is, in most cases, sufficient to raise the roadbed to the desired height. The corduroy road, though usually short-lived, frequently lasts for several years, when well constructed and made of good material, such as oak. A road of this character between Yorktown and Williamsburg, Va., constructed by Gen. McClellan, during the late war between the States, still remained some ten years ago, when the writer visited that section; and it was then in fair state of preservation.

Plank Roads.—Plank roads, like corduroy roads, are generally constructed in swampy or boggy districts, where lumber can be had at small cost. This class of roads was quite common throughout the piney woods region of the South, during the days of the stage coach; but they are now rarely met with, except as

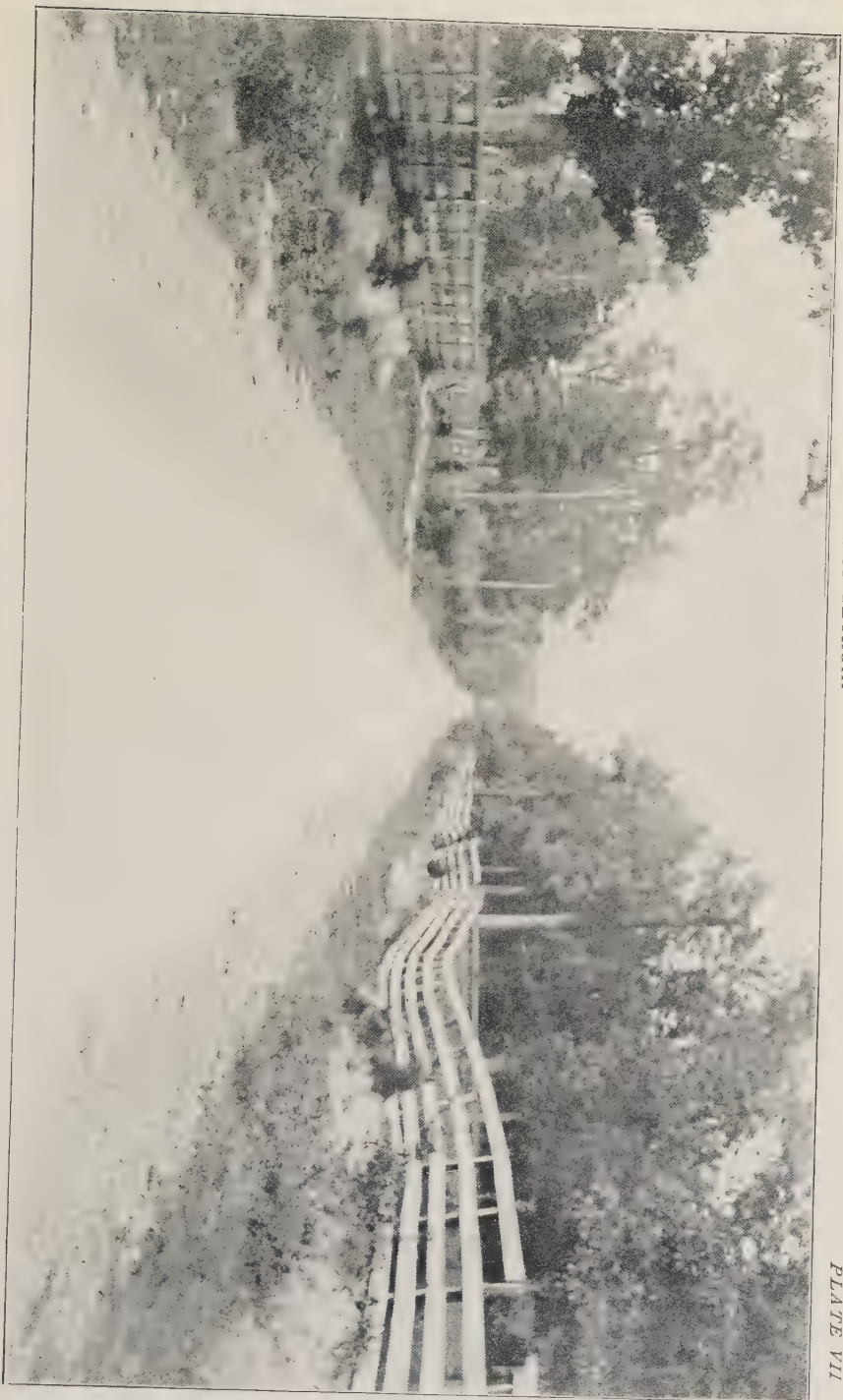
short cause-ways traversing marshy ground. Plank roads, when first constructed, have all the essential qualities of a first-class roadway. The surface is smooth, slightly elastic, and free from dust or mud. These favorable conditions, however, are only of short duration, unless the road is well constructed and is kept in good repair. The effect of the sun upon the planks causes them to warp, and the result is a very uneven surface, which in turn induces rapid wear of the planks; and the final consequence is a very undesirable roadway. The method commonly adopted in constructing plank roads is to lay down two parallel lines of sleepers, lengthwise with the road, on which the planks are to be placed. The sleepers should be about five feet apart, and made of durable wood. They should be of sufficient size to form a stable foundation for the road-covering above. Upon this foundation, a floor is laid, of planks from three to four inches in thickness, and about eight feet long. It is always best to have some of the planks a few inches longer than others, so as to enable the wheel to easily regain the plank-way, after being forced from it by the passage of other vehicles. Yellow pine is probably the best material for the construction of plank roads. It is very durable, and at the same time, not so liable, as many other timbers, to be warped by the sun.

Earth Roads.—Earth roads are the most unstable and short-lived of all roadways. Nevertheless, on account of their cheapness, they must of necessity constitute the great percentage of our highways in the South, for many years to come. On this account, the construction and maintenance of such roads should receive more attention than is usually given to the subject in works on highway-construction.

The common earth road, as long as it remains dry, smooth and free from dust, is an ideal country-road. Its advantages are well illustrated by the choice of the teamster, who invariably selects it during the dry season in preference to the macadamized road, when the two lie side by side, and each is kept in good condition. The earth road, when at its best, is elastic and easy upon the

horses' feet, and is almost entirely free from the surface irregularities, which are common to both broken-stone and gravel roads.

One of the greatest difficulties to be overcome in the construction of earth roads is the question of drainage. This should receive special attention, if the best results are to be obtained from roads of this kind. Every observant person has noticed, that certain portions of earth roads are nearly always in good condition, regardless of the weather; while other portions of the same road are invariably in bad condition. This variation in the state of the road-surface, at different points, is due, in the majority of cases, almost entirely to drainage. An earth road is rarely ever in as bad condition on a gentle slope, as it is on level ground. In other words, the quagmires and mud-holes are usually found in hollows or on level ground, and not on the hills, where the drainage is more perfect. This class of roads, in many places, especially where the soil is somewhat sandy, frequently needs no further drainage than that accomplished by shallow side-ditches, and by a properly crowned surface. In other instances, deep side-ditches or under-ground drains are essential to a dry roadway, particularly, if the roadbed is formed of clay. On account of the absorbent and retentive power of clay, it is one of the most unsatisfactory materials used in road-construction. Having once become saturated with water, the clays readily become soft, plastic and difficult to drain. It is practically impossible to construct, of such material, anything like a good road, unless the drainage is perfect. For this reason, it is always advisable to mix, with the clay, sand or gravel, which greatly improves it for surfacing. Roadbeds, made of such material, are usually quite satisfactory, if the side-ditches are kept open and the ruts are filled as soon as they are made. Some engineers advise the use of a layer of sand, two or three inches deep, on the surface, where the clay is tough and adhesive. A cover of this character is inexpensive and is said to pack well under traffic during the dry season. Furthermore, it prevents the clay from becoming sticky, in wet weather. Ashes, coal-dust, furnace-slag, and the refuse obtained from the burning of pyrites



VIEW ON THE KINGSTON ROAD IN FLOYD COUNTY, 2 MILES FROM ROME, GEORGIA, SHOWING MACADAM CONSOLIDATED AFTER TRAVEL.

in the manufacture of sulphuric acid are also used for a similar purpose. The last named road-covering makes an excellent surface, which is always compact and free from dust. Nevertheless, it has one very serious objection, especially in cities and towns, namely, its destructive effect upon shade-trees growing near the roadway. It seems quite probable, however, that this objection could be removed, by allowing the material to become thoroughly leached, before putting it in place.

In repairing roads surfaced with the materials named above, it is always best to fill the ruts and depressions with similar material. In no case, should stones or clay be used for this purpose ; as both have a tendency to aggravate the evil, in place of removing it. Highway constructors sometimes resort to the burning of clays, in order to make them porous and more suitable for road-surfacing. This process of treatment, however, is somewhat expensive ; and it could hardly be considered practical in the construction of common roadways.

Sand roads are often as difficult to put in good condition as clay roads. This trouble arises mainly from the tendency of the sand to slip and shear, when under the action of the wheel. In order to overcome the unstable condition of the sand, it is necessary to mix it with some foreign material, which will counteract its tendency to shear, and thereby cause the particles to adhere to each other with greater force. Common clay is one of the best and most satisfactory materials, that can be used for this purpose. A layer of it, from four to six inches thick, placed upon the surface of a sandy road, will greatly improve its condition. The sand, sooner or later, mixes with the clay, and thus forms a more or less porous road-covering, which is free, in a great measure, from those objectionable qualities, found in either the clay or sand road alone. Straw, leaves, twigs, brush, refuse from sorghum-mills, and saw-dust have all been effectively used upon sandy roads, in improving their condition. It is claimed, that any of these materials cause the surface of the sandy roadway to become comparatively hard and well suited for even heavy traffic, in a short time. Mr. Potter

strongly recommends the following method of constructing roadways, in alluvial districts :—

“The road is slightly raised above the original surface of the ground, and thoroughly rolled ; then a few inches of brush or coarse grass is put in, the first layer being laid with the ends or fibres pointing across the line of the road, and the second, lengthwise. The total thickness of these two layers will depend upon the quality of the material used, and upon the weight of the top layer of earth, which will cover it. In all cases, these layers should not be so thick as to prevent their compacting, with undue elasticity, or tendency to “give,” under the weight of a loaded vehicle. This method does not insure permanent excellence ; but, as long as the grass- or brush-layer retains any of its original form or qualities, it will greatly hasten the drying of the road after a wet season, and will tend to greatly drain it at all times ; for no reasonable amount of pressure can be exerted by weight upon the road-surface, that will tend to close or obstruct the little spaces between the various bits of straw or brush.

Whatever material is used in the improvement of an earth road, it is of prime importance, that its surface should be rounded, hard, and as compact as possible. Traffic alone will accomplish this desired result in time, if the road is properly drained. The main objection to this method of hardening the road is the tendency of the wheels to form ruts. To overcome this difficulty and to obtain satisfactory results, the roadway demands constant attention, until the loose earth is thoroughly compacted. The same object is more speedily and effectively accomplished by the use of the roller, and its general adoption is strongly advocated by all the leading highway constructors. It is true, that the roller adds slightly to the first cost of a roadway ; but, in the long run, its use is undoubtedly economy, as it increases the effectiveness of the roadway, and, at the same time, makes it much more durable.”

CHAPTER IV

MAINTENANCE AND REPAIR OF ROADS

A roadway having been properly constructed and thrown open to traffic, the next duty of the roadmaster is to see, that it is seasonably repaired, and kept as near as possible in its original condition. Many unthinking persons are of the opinion, that a road, when constructed of broken stones or other durable material, will remain in good condition for an indefinite time, with but little or no attention. Such, however, is a most grievous error, as is well attested by the practical experience of all road-builders. It would, indeed, be a difficult matter to select any of the varied products of man's handiwork, that demands more constant and watchful attention than our common roadways. The forces, active in their destruction, are varied and continuous; and, if they are not retarded in their incipency, dissolution will speedily follow. In no instance, is the old adage, "A stitch in time saves nine," more forcibly illustrated, than in this.

Two different methods of road-maintenance are in general use, namely, the "periodical method" and the "continuous method." The former consists in going over the road two or three times each year, with a squad of hands, and making such repairs as are necessary to keep the road in a passable condition. This method is usually unsatisfactory, and is rarely ever productive of first-class roadways. This is due to the road's often becoming well-nigh impassable, in places, before the necessary repairs are made. The natural consequence of such a system is fairly good roads for only short periods, two or three times each year; and, during the remainder of the time, they are necessarily bad. "The continuous method" is far more satisfactory; it is generally adopted in

all sections of the country, where first-class roads are maintained. Under this system, repairs are always made at the opportune time by laborers constantly employed for that purpose; and no break or defect in the road is allowed to advance beyond an incipient state. The practicability of this method of maintaining common country-roads is well illustrated by the following statement of Mr. J. O. Sanford, of the Vermont Board of Agriculture:—¹

“The main road through our town, six miles long, not only takes the travel of the other roads, but is the thoroughfare, by which the inhabitants of other towns reach the city with their produce, lumber, wood and a great deal of heavy trucking. The best farmers live along the road, and have enough business of their own, without caring for a section of road. Because of this, and for various other reasons, I conceived the idea of employing one man to keep this road, and therefore engaged a faithful man, with his horse, the town furnishing a cart.

“He was employed from spring to fall, and his instructions were to begin at one end and work one mile each day, covering the entire route each week and fixing the worst mud-holes, using the best road material at hand; and, at the close of each day, to pass over the mile worked, gathering the loose stones, and putting them, where they would give no more trouble. * * * * *

There was much ridicule and prejudice against this system of management for a time. The man employed was instructed not to participate in any discussions on the subject; not to answer questions relative to the road or his work upon it; and to refrain from talking about the matter generally, on penalty of being discharged. Other people talked and ridiculed; but the work went on; and after a few months the condition of the road improved, and people noticed the fact. They also discovered, that the expense was not large; that all the work done was remedying defects and at the same time preventing greater ones. And so the work went on and prejudice died out. At the next annual town-meeting, the people without opposition continued the system;

¹ Circular No. 24, U. S. Dept. of Agri., Office of Road Inquiry.

and at the last town-meeting, they elected the Road Commissioners for three years, with the same system of road-management. The general results are, that much better roads are secured at less expense ; and the tax-rate for highways has been reduced each year as the roads grew better."

The merits of this system of road-maintenance is highly commendable, and if it were more generally adopted throughout the country, the result would be a speedy improvement in highways. The system is applicable, not only to broken-stone roads, but also to earth roads. If the best results are to be obtained from this method of repairing roadways, it is essential, that the men employed should be faithful in the performance of their duties, and have a practical knowledge of road-construction. Furthermore, they should be able to so classify and plan their work, that the various improvements and repairs could be carried on, at all seasons of the year. When the method, thus outlined, is thoroughly systematized and put in working condition, it is practically the same plan, that is adopted by "section-bosses," in maintaining railroads.

There are two systems of maintaining highways by the continuous method of repair now in common use ; (1) by contract with private parties ; (2) by laborers regularly employed for that purpose by the road authorities. The contract system, as a general rule, proves to be unsatisfactory, on account of the difficulty of forcing the contractors to fulfil their obligations ; while the hired-labor system, on the other hand, meets with universal approval and is always fruitful of satisfactory results. The latter system is in vogue, both in this country and in Europe, wherever good highways are kept up. The expense of maintaining a roadway in good condition depends largely upon the perfection of its construction, the nature of the traffic, and the character of the material used in surfacing. If the road is not properly constructed, the wear and tear of the destructive forces becomes much more effective ; and, in a comparatively short time, it becomes impassable. The hardest roads to maintain are those defective in drainage. In repairing

roadways, this defect should be especially guarded against, by keeping the side-ditches and the under-drains always open. The amount of traffic, which passes over a road also affects, in a considerable degree, the cost of maintenance. This is due, not so much to the actual wear of the material, as to the breaking up of the hardened surface by the wheels of heavily loaded vehicles. A road under light traffic, if well constructed, may last for several years with little or no repairs; whereas, the same road under heavy traffic would likely go to pieces in a short time. Furthermore, the nature of the material used in forming the hardened surface of a road affects the cost of repairs in a marked degree. Some surfacing materials, owing to their toughness and a tendency to bind together in a perfect bond, are quite durable; while others are soft, and possess very inferior wearing qualities. Trap rock, for instance, under a similar system of repairs, will last many times longer for surfacing than inferior limestone or shale.

A good roadway is one, that has a smooth, hard surface, free from dust and mud. In order to secure these essential conditions, the surface of the road must be kept clean, well drained and properly repaired. The first of these conditions, namely, cleanliness, is of very great importance. Especially is this true of broken-stone roads. If the material, which originates from the wear of stones, is not removed from the roadway, it soon becomes quite thick, and finally interferes, more or less, with travel. In wet weather, the waste from the broken stones forms mud; while in the dry season it exists as dust, which is scarcely less objectionable. Moreover, when this material accumulates upon the surface, even to the depth of only a fraction of an inch, it causes the wheel to leave a track, along which, sooner or later, a rut is formed by running water, so that in a short time the continuity of the hardened surface is broken by the deepening of the rut, and the roadway becomes rough and uneven. Besides the formation of ruts, the waste from the broken stone also obstructs surface-drainage, and thereby gives rise to numerous mud-holes. These in turn soften the hardened way and allow the wheels of vehi-

cles to cut rapidly through the layers of broken stone. In order to reduce to a minimum these evils, resulting from an accumulation of waste upon the surface of a stone road, it is essential, that all foreign materials should be removed from the surface as fast as they accumulate. This is best accomplished by sweeping, when the waste is dry and in the form of dust. Both hand- and machine-brooms are used for this purpose. The former, which is the most suitable for country-roads, is usually made of birch or willow twigs. The sweeping of a road may appear at first thought to be a very expensive undertaking. It is however not so costly as it seems. The accumulated dust on roadways usually collects at certain favored places, and is not evenly distributed over the entire surface. Consequently, in removing the dust from the road, only a comparatively small part of the entire superficial area has to be gone over with the broom. The dust, when it is removed from the surface, should be so disposed of, that it will neither interfere with the drainage of the side-ditches, nor be again distributed over the road by the action of the wind. Too much sweeping should also be guarded against. Otherwise the fine material forming the bond between the individual stones is weakened; and they become easily loosened and removed from their position. A road kept too clean is apt to "ravel" and go to pieces rapidly under traffic.

When the surface accumulations are in the form of mud, it is necessary to remove them by means of hoes and scrapers. Care should always be taken, in the use of these implements, to see that the stones are not loosened and removed from their bedding. To avoid this danger as much as possible, it is advisable to use wooden hoes and scrapers. If the road-surface is not hard and well bonded, it is usually best to make no attempt whatever to remove the surface accumulations, as the injury to the surface is likely to be greater than the benefit derived from the removal of the dust.

The amount of actual wear upon the surface of any well-constructed road is comparatively small. The destruction of the roadway generally arises from the formation of ruts produced by

the vehicles following each others' tracks. To prevent the occurrence of these ruts, and also to repair them, when once formed, is one of the many duties devolving upon the person in charge of the roadway. As previously stated, the best way to prevent the occurrence of ruts is to keep the surface of the road as clean as possible, so that the wheels of the vehicles will leave no track. Any depression or rut, however small, rapidly increases in size; and they should always be repaired at the earliest opportunity. Potter says, that, when these breaks in the surface occur, all water and mud should be removed from them, and the surrounding surface should be loosened to the depth of about one inch, by means of a pick. A layer of broken stones, in the case of a macadamized road, should then be spread over the loosened spot, care being taken to bring the large stones to the center or deepest part of the depression, and the smaller ones to the edges. The stones should be beaten, as they are put into place, until they become thoroughly united with the broken stone of the original surface. In order to secure a quick and a complete bond between the new and the old material, it is always well to sprinkle the broken stone before ramming. Even when every precaution in such repairs is taken, it is often well to make frequent examinations, in order to see, that the material is properly consolidated, and that it forms an even surface with the rest of the roadway. If the mended places are higher than the corresponding surface, they will soon give rise to depressions on the opposite side of the trackway; while, if the opposite conditions prevail, the former depression or rut will again appear in an exaggerated form. It is also essential, in repairing ruts and depressions, to use material similar to that made use of, in the original surfacing. Otherwise, it will wear unevenly, and give rise to a rough surface.

When the stone-covering of a roadway becomes reduced in thickness, by continuous wear, so that it is no longer able to support the traffic, which is to pass over it, two different methods of repair are adopted. One of these methods, called the patch-work method, consists in increasing the thickness of the stone-covering



A GRAVEL-PIT NEAR AUGUSTA, GEORGIA.

over a small area of the road at one time. This plan of repair seems to be best suited to roads of light traffic, where the rate of wear is naturally low. No broken-stone surface wears equally rapid at all points along its course. Consequently, if the weakened places are, from time to time, renewed to their original condition, the roadway may continue in a fair condition for an indefinite period. The other method of road-repair consists of a complete removal of the entire road-covering at one time. In accomplishing this work, the old material is first loosened up and then rolled, after which the new material is placed on and consolidated. The object in removing the old material is to insure bond between it and the new. This latter method is usually adopted, in repairing roads much used.

In repairing earth roads, the chief part of the work, which consists in renewing the former crown of the surface, opening up the side-drains, and filling the ruts and depressions, can usually be accomplished quite well by means of a road-machine. "There is hardly a month in the year," says Potter,¹ "when the road-machine cannot be used to an advantage on the road; but the spring is the best time to do efficient work, because the soil is loose and the roots of grass and weeds do not interfere. Every spring, before the ground becomes too hard, the road should be gone over thoroughly with the road-machine; the ditches cleaned out, so that water may have a free outlet; ruts and holes filled; elevations in the road and the shoulders on the side of the road, planed off; the grade, improved; and the road, put in a good condition generally. In repairing a road, which is in fair condition, commence at the ditch and work towards the center, scraping lightly with the entire length of the blade, till the last rounds the middle of the road." Where the machine is not used, these various repairs must be accomplished by means of manual labor, which adds greatly to the cost of maintenance.

¹ Country Roads, page 31.

CHAPTER V

ROAD MATERIALS

The three essentials of a road-surfacing material are hardness, toughness and the ability to unite into a compact bond. It rarely happens, that all these qualities are met with, in a high degree, in any one variety of stone. Massive quartz, for instance, is remarkably hard ; but it is at the same time quite brittle, and its powdered dust possesses little or no cementing qualities. The hardness and toughness of a rock depends, not so much upon its mineral composition, as upon the physical structure and the condition of the individual minerals, of which it is composed. Rocks having the same mineral composition may differ widely in their structure, and also in their usefulness as road materials. These differences of structure have generally been brought about by a re-arrangement of the mineral constituents, so that an originally massive rock may assume a schistose or laminated structure. The minerals in such rocks are orientated, that is, their longer axes all have the same direction.¹ This arrangement of the minerals causes the rocks to break with greater ease along certain lines than along others, which unfits them, in a large measure, for road purposes. A rock, to be well suited for macadamizing material, should possess a massive structure, and should have no weak lines, along which it can be easily broken. These conditions are generally met with, in rocks of igneous origin. The minerals in these rocks occur in the form of grains, as in most of the granites ; or they may occur in the form of crystals, giving rise to a felt-like structure, as is seen in many of the so-called trap rocks. The latter structure is usually characteristic of great toughness ; and it en-

¹ See Plate III.

ables the rock to undergo long and continued wear without going to pieces. The binding quality of a stone used for road-surfacing is scarcely of less importance, than its hardness and toughness. Prof. Shaler, in speaking of this quality, says:¹ "This process of cementation, which gives solidity to the macadam road is mainly due to, and to be measured by, the energy of cementation of the dust on the broken stones, either that made in crushing the material, before it is applied to the way, or that produced by the rubbing of the bits together, which is brought about by the action of the roller or the wagon-wheels; furthermore, that the binding action is, as to its value, determined not only by the intensity, with which the particles hold together when first set, but by the extent, to which this dust may re-cement, when broken up by the wheels, after it has been watered either artificially or by occasional rains." The binding quality of the various stones used for road purposes is quite variable. It reaches its greatest degree of development in the diabase variety of trap, limestones and chert; while it is almost entirely wanting in quartz and sandstone. Roads surfaced with the last two varieties of stone should in all instances have some foreign material used as a binder. Otherwise, the broken fragments will be difficult to compact into a hardened surface. The following is a short description of some of the most important rocks employed in road-construction:—

TRAP ROCK.—The term, "trap," is from the Swedish word "trappa," meaning a stair or step. It was first applied to igneous rocks, weathering in the form of massive steps. The term, as now commonly used, has a rather indefinite meaning. However, it is frequently applied to any dark, massive, eruptive rock, whose mineral constituents are not readily made out, without the use of the microscope. This class of rocks has received various local names, given from their natural or fancied resemblance to certain minerals, or other object. A common name applied to them throughout the Southern States is iron-stone or iron-rock. "Nigger-head" rock is also frequently used. The last of these seems to

¹ American Highways, by N. S. Shaler, p. 54.

be somewhat descriptive, and evidently has reference to its peculiar rounded mode of weathering, and its unusual hardness. All the trap rocks are of igneous origin, and commonly occur in the form of dikes, which were originally fissures in the earth's crust extending to great depth, through which the trap rock welled up in the form of melted lava. The great rapidity, with which these rocks cooled, caused them to be very fine grained and compact. Many of them have such exceedingly fine structure, that it is often impossible, to identify the individual mineral constituents, without the aid of the microscope. The most common varieties of trap rock used in road-construction are diabase and diorite. These rocks differ from each other, both in mineral composition and in physical structure.

The diabases are made up of plagioclase and augite, and possess a peculiar interlocked structure, which gives to these rocks their remarkable toughness.¹ The feldspar occurs in the form of long, narrow, lath-shaped crystals, surrounded and enclosed by broad, angular plates of augite. All the diabases are of a dark color, and are usually very homogeneous in texture. As a general rule, they have a fine texture, and always break with great difficulty. The fragments, whether broken by hand or by the crusher, are usually irregular and angular, which permits them to become easily consolidated into a compact, hard mass, by the action of the roller. The diabases, which are the most durable of all rocks for road-surfacing material, are pretty generally distributed throughout the eastern part of the United States. The trap rock of the Palisades on the Hudson river, and many of the intrusive rocks of the Connecticut valley, New Jersey, Maryland, Virginia, the Carolinas and Georgia, are diabases. In Georgia, the diabases occur as dikes, varying in thickness from an inch to one or more hundred feet. They are readily distinguished from all other rocks by their mode of occurrence, great toughness, high specific gravity and their peculiar manner of weathering into rounded boulders.

¹ See Plate IV.

The diorites resemble the diabases very closely, in general appearance. They differ from them, however, in containing hornblende, in the place of augite; also, in their granular structure. The diorites, as a general thing, are not so tough as the diabases; and, as a consequence, they are not so suitable for road-surfacing. Nevertheless, they are extensively used for this purpose, and are said to possess excellent cementing and wearing qualities. This class of rocks generally occurs with granites and gneisses, and often has a laminated or schistose structure. The massive variety is always preferred for road material; as it forms a more complete bond, and the fragments are not so easily crushed by action of the wheel. A number of other varieties of dark-colored rock, used for road material, are often called trap rock. The most common of these are the gabbros, the hornblende-schists and the norites, all of which make good road material, unless they are laminated or are very coarse-grained.

GRANITE. — The granites, including the gneisses and syenites, have a more or less extensive use in road-construction. They are, however, inferior to trap rock, both in toughness and in binding quality. Many of the true granites, especially those having a fine grain and a homogeneous texture, make a fair road material. One of the principal defects in nearly all granites, one that affects their wearing quality when used as road-surfacing, is the unsound condition of their feldspars, one of their essential minerals. By an examination of a thin section of almost any granite under the microscope, it will be seen, that many of the feldspar crystals are more or less altered to kaolin, the most commonly occurring member of the clay group of minerals. This altered condition of one of the leading mineral constituents of a granite greatly reduces its power to withstand abrasion; and, as a result, it is readily ground to powder by the action of the wheel. Mica, when it is abundant in granite, is also an element of weakness; as it is readily affected by atmospheric agencies, thereby causing a disintegration of the stone. It is a good rule, in constructing a broken-stone road, never to use granite for surfacing material, unless it has a

fine texture and the feldspar is in an unaltered condition. Coarse-grained granite with the feldspar partially decomposed is but little improvement on common coarse sand, in the construction of a hardened way.

The syenites, which differ from the granites, mainly in the absence of quartz, generally consist of orthoclase and hornblende. These rocks are always granular like the granites; but generally they are fine-grained, more compact and better suited for road-construction. The best varieties of syenite for road material are those having a very dark color, which indicates the presence of a large quantity of hornblende, a mineral constituent, to which the rock in a great measure owes its toughness.

The gneisses, which are more abundant than either of the above named rocks, are also quite extensively used for road purposes. The only difference between the gneisses and the granites is the banded structure of the former, which gives to it a stratified appearance.

Closely related to the gneisses, is another class of rocks, known as *schists*. These rocks also have a limited use in road-building. They are, however, a very inferior road-metal; and they should never be used, if any other material is at hand. The various rocks, here included under the general head of granites, are of very common occurrence in the eastern part of the United States. They make up, in a great measure, the majority of the crystalline rocks, of ancient though doubtful age, forming a narrow belt, extending from Vermont to Alabama. All the rocks, with few exceptions, belonging to the Crystalline Area of North Georgia, are of this class.

LIMESTONE.—The limestones, together with the dolomites, are widely distributed, and are probably more extensively used for macadamizing purposes than all other kinds of stones combined. When compact and semi-crystalline, they make a fair road material, the cementing property of which is of the highest quality. The crystalline varieties called marble are not so suitable for road-construction, as their granular structure causes them to be easily

crushed by the wheel. Many of the limestones also contain a high percentage of clay, and are quite heterogeneous in structure. Such stones possess an excellent cementing property; but they are almost invariably defective, in weathering qualities, which renders them undesirable for road-surfacing. The dolomites are generally harder and more compact than the true limestones; and, as a consequence, they are preferable for road-construction. Prof. Shaler, in speaking of the durability of limestones, says:—¹ “In practice, limestone wears, under a given amount of traffic, at least twice as rapidly as the trappean rocks. In cases, particularly where the slopes are steep, so that the dust readily washes away, or where the road is exposed to a strong wind, the rate of wear is about four times as rapid as it would be, if the road were covered with the best quality of trap.”

SANDSTONE.—Sandstones are indurated or hardened beds of sand. The individual granules, of which they are composed, are cemented into a compact mass by a ferruginous, calcareous, argillaceous or siliceous matrix. The sandstones usually possess little or no binding property; and, furthermore, they are generally soft and easily crushed. These qualities render this class of stone almost worthless for road-surfacing material. Quartzite, a metamorphic sandstone, is far more valuable as a road material. This variety of sandstone is frequently quite tough, and makes a very durable road material. It is essential, however, in most cases, to add some foreign material to the quartzite, in order to make the broken fragments unite into a hardened surface.

CHERT.—Chert is a name, applied to a cryptocrystalline variety of quartz, closely akin to flint, and occurring as layers or nodules in many of the older limestones. When the limestones are dissolved and carried off in solution by water, these flinty layers and nodules remain unaltered, and often accumulate, in thick deposits. When this material does not contain too much clay, it makes an excellent road-covering, especially when the traffic is light. The cementing quality of chert is probably sur-

¹ Op. cit., p. 60.

passed only by limestone and diabases ; but its wearing quality is not so satisfactory, owing to its greater brittleness. This class of road material is quite common throughout the Southern States, wherever the Silurian limestones are present. It occurs in the northwestern portion of Georgia in great abundance, where it has been used more or less extensively for several years for surfacing highways.

SHALE AND SLATE.—Shales and slates, which are indurated or hardened clays, are of very common occurrence ; but, as a general rule, they are brittle, and so easily affected by atmospheric agencies, that many of them are but little better than common clay for constructing hardened ways. When these rocks are of a sandy nature and contain a considerable amount of lime, they may be used for road-surfacing ; but, even then, it is advisable to mix with them some other material, which will give to the hardened way a more lasting surface.

GRAVEL.—Gravel is composed of rounded pebbles, varying from the size of a pea to that of an egg. When they are of a larger size, they are often called shingle. Gravel may consist of almost any variety of rock ; but quartz is the most common, because of its hardness and great power of resisting abrasion. These water-worn pebbles are frequently found forming extensive deposits along sea-beaches, both ancient and modern, and they are also quite abundant in the beds of streams, especially if the streams are rapid and take their rise in the Crystalline area. Deposits of water-worn gravel constitute one of the chief characteristics of the LaFayette formation, which consists of a belt, many miles wide, extending through Maryland, Virginia, the Carolinas and the Gulf States. Gravel, obtained from this source, has quite an extensive use for road purposes along the western margin of the Coastal Plain. The great hardness of gravel, together with its unusual toughness, especially fits it for surfacing material. However, it is at the same time, on account of its rounded form, very defective in binding quality. To overcome this defect, it is often necessary to mix with the gravel some foreign material as a binder,

to secure a compact hardened surface. There is also another variety of gravel, having an angular shape, often called pit-gravel, which is more or less extensively used in road-surfacing. This class of gravel originates as a detritus from the uneven weathering of limestones, sandstones, shales and other rocks, and is usually found in considerable beds at the base of hills or ridges, where it occurs in the form of talus. To this class of gravel, the chert spoken of above properly belongs.

SHELLS.—Shells are frequently used for surfacing roads, especially in the vicinity of the sea-shore, where they often occur in beds several feet in thickness. This material makes an excellent hardened way for light traffic. It binds well, wears evenly, and is comparatively free from dust. Oyster shells, which often accumulate in immense heaps about packing houses, are the best shells for road-surfacing. They are not so fragile, as the beach-washed shells; and, as a consequence, they are more durable and freer from dust. Prof. Shaler places shells as equal in value to ordinary limestone for road-construction, when the cost of preparation is taken into consideration.

The following table, taken from the annual report of the Massachusetts Highway Commission for 1896, gives the specific densities, coefficients of abrasion, cementing value, and re-cementing value of stone, as obtained from a series of laboratory tests:—

—————) (—————

Table Showing Specific Densities, Coefficients of Abrasion, Cementing Values and Recementing Values of Stones Tested

NAME OF STONE	CITY OR TOWN	1	2	3	4	5
		Specific Den- sity	Coefficient of Wear	Cementing Value	Cementing Value of 30 Gram Briquet	Recementing Value of 30 Gram Briquet
Diabase	Saugus, Essex Co., Mass., ...	3.03	21.22	—	—	—
Trachyte	Newton, Middlesex Co., Mass., ...	2.80	20.79	—	—	—
Olivene diabase	Newberry, Essex Co., Mass., ...	—	20.40	—	—	—
Diabase	Lynn, Essex Co., Mass., ...	3.03	20.37	—	56	29
Diabase	Lynn, Essex Co., Mass., ...	3.03	19.77	—	—	—
Diabase	Saugus, Essex Co., Mass., ...	3.03	18.25	—	—	—
Diabase	Lynn, Essex Co., Mass., ...	2.99	18.17	—	—	—
Camptonite	Salisbury, Essex Co., Mass., ...	—	16.76	—	—	—
Diabase	Newburyport, Essex Co., Mass., ...	—	16.10	—	40	34
Diabase	Saugus, Essex Co., Mass., ...	3.01	16.08	—	42	20
Felsite	Boston, Suffolk Co., Mass., ...	—	16.06	23	109	31
Diabase	Saugus, Essex Co., Mass., ...	3.01	16.02	—	121	39
Diabase	Medford, Middlesex Co., Mass., ...	3.03	15.82	—	—	—
Olivene diabase (poor specimen)	West Springfield, Hampden Co., Mass., ...	2.96	15.60	82	—	—
Augite diorite (poor specimen)	Salem, Essex Co., Mass., ...	2.92	15.55	27	58	19
Diabase	Quincy, Norfolk Co., Mass., ...	2.96	15.21	—	—	—
Olivene diabase	Brookline, Norfolk Co., Mass., ...	2.99	14.71	—	81	28
Felsite	Lynn, Essex Co., Mass., ...	2.66	14.66	—	—	—
Quartz diorite	Newbury, Essex Co., Mass., ...	—	14.45	—	—	—
Olivene diabase (coarse grained)	Everett, Middlesex Co., Mass., ...	2.87	13.87	—	—	—
Hornblende granite	Duxbury, Plymouth Co., Mass., ...	2.68	13.46	—	—	—

Felsite	Revere, Suffolk Co., Mass.,	2.65	13 21	11
Augite nephelene syenite	Gloucester, Essex Co., Mass.,	—	12 63	5
Hornblende granitite	Rockport, Essex Co., Mass.,	—	12 57	—
Augite diabase (poor specimen)	Meriden, Conn.,	2.83	12 50	—
Felsite	Lynn, Essex Co., Mass.,	—	12 30	6
Schist	Chester, Hampden Co., Mass.,	—	12 21	11
Hornblende granitite	Waltham, Middlesex Co., Mass.,	2.62	12 16	16
Schist	Lee, Berkshire Co., Mass.,	—	12 15	—
Quartzite	Lee, Berkshire Co., Mass.,	2.60	11 65	—
Gneiss	Lee, Berkshire Co., Mass.,	—	11 43	—
Hornblende diorite	Brookline, Norfolk Co., Mass.,	2.87	11 40	23
Hornblende granitite	Gloucester, Essex Co., Mass.,	2.64	11 03	31
Hornblende granitite	Northampton, Mass.,	2.74	10 69	6
Magnetite corundum gneiss	Chester, Hampden Co., Mass.,	—	10 62	—
Hornblende granitite	Quincy, Norfolk Co., Mass.,	2.66	10 16	35
Field stone (erratics)	Plymouth, Plymouth Co., Mass.,	—	10 10	—
Hornblende granitite	Orange, Franklin Co., Mass.,	—	9 78	18
Limestone	Great Barrington, Berkshire Co., Mass.,	—	9 52	27
Field stone (erratics)	Nantucket, Nantucket Co., Mass.,	—	9 47	—
Limestone	Pittsfield, Berkshire Co., Mass.,	2.82	9 38	—
Diabase (very coarse grained)	Somerville, Middlesex Co., Mass.,	2.86	9 28	15
Field stone (erratics)	North Attleborough, Mass.,	—	9 09	—
Quartzite	Diamond Hill, Cumberland, R. I.,	—	9 07	34
Hornblende granitite	Saugus, Essex Co., Mass.,	—	8 99	—
Field stone (erratics)	Tisbury, Dukes Co., Mass.,	—	8 88	9
Conglomerate	Mattapoisett, Mass.,	—	8 78	—
Slate (Cambrian?)	Newton, Middlesex Co., Mass.,	—	8 67	—
Chert	Somerville, Middlesex Co., Mass.,	2.75	8 48	14
Schist	Gordon County, Ga.,	—	8 35	—
Hornblende gneiss	Lenox, Berkshire Co., Mass.,	2.84	8 04	—
	Buckland, Franklin Co., Mass.,	—	7 94	27
			8	—

Table Showing Specific Densities, Etc.—Concluded

NAME OF STONE	CITY OR TOWN	1	2	3	4	5
		Specific Den- sity	Coefficient of Wear	Cementing Value	Cementing Value of 30 Gram Briquet	Recementing Value of 30 Gram Briquet
Limestone (siliceous)	Tomkins Cove, N. Y., ...	2.84	7.84	16		
Field stone (erratics)	Holden, Mass., ...	—	6.58			
Field stone (erratics)	Whitman, Mass., ...	—	5.93			
Granitoid gneiss	Paxton, Worcester Co., Mass., ...	—	5.01			
Marble	Lee, Berkshire Co., Mass., ...	2.74	2.85			

"In this table, the stones are arranged in the order of their power of resisting abrasion. Column 1 contains the specific density of the stone; column 2, the coefficient of abrasion; the next column gives the number of blows required to stress the 2.5-c.m. briquets to their elastic limits; column 4 gives the same data for the first testing of 30-gram briquets prepared for the re-cementation test; and the next column gives the number of blows, that the re-cemented briquets will stand, before reaching their elastic limit." The table, in a general way, shows the relative value of the stones tested for road materials; but Mr. Page says, that the data here presented are too limited to be discussed in a judicious manner.¹

¹ These tests have been greatly extended, since the above was written. See Report of Mass. Highway Commission for 1899.



CHAPTER VI

TOOLS AND MACHINES USED IN HIGHWAY CONSTRUCTION

Many tools and machines have been devised, from time to time, for the special purpose of constructing and maintaining highways. The most useful of these implements are the plows, scrapers, road-graders, rock-crushers and rollers. Of late years, these several devices have played a very important part in the economy of road-building. They not only greatly reduce the cost of constructing roads; but they also lessen the expense of maintenance in like degree. It has been claimed, that the use of these implements diminishes by one half the cost of building and maintaining first-class roadways. That this statement is not overdrawn, seems evident, if we take into consideration the fact, that much of the work of grading etc., which was formerly done by manual labor, can now be executed by horse or by steam-power, through the invention of the above named implements. Improved and modern road-making machinery is as essential and important in the construction and maintenance of highways as is the self-binder in the harvest-field, or the mower and rake in the meadow.

PLOWS. — Plows constructed for road purposes should possess unusual strength. The beam, when made of wood, should be of the best hickory or white-oak, and protected by iron straps on its under and upper sides extending from the clevis to the standard. The handles should also be of like material, similarly protected, where they are likely to be injured by contact with the hard ground; and they should be securely bound to the beam by means of iron rods. Some manufacturers construct road-plows with steel beams and handles. Such plows are most

economical, where they are constantly exposed to the weather, as they cannot rot. The share, mould-board and coulter should all be made of the best of plow-steel, and so patterned as to best execute the special work, for which they are designed. There are several varieties of plows manufactured for road purposes, each of which is claimed by its agent to possess peculiar merits. The plow most useful in common road-construction is the grading-plow, which weighs from 100 to 150 pounds, and is intended for four horses. Lighter plows are frequently used; but they are generally unsatisfactory in hard ground.

Fig. 19



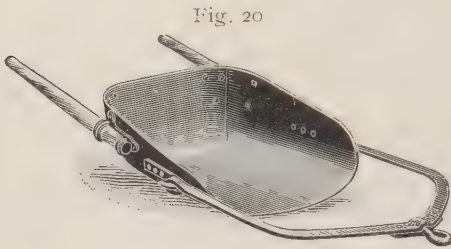
A Road-Plow.

ROAD SCRAPERS.—There are two different kinds of road-scrapers in common use, namely, the drag scraper and the wheeled scraper. The former is a steel or iron scoop, with a capacity of from three to seven cubic feet, and weighing from 90 to 100 pounds. To the sides of the scoop near its anterior end is fastened an iron bail, to which the horse is attached; while to the rear, on either side, are the handles, used in manipulating the scoop during the process of loading and unloading. These scoops are simple structures, easily repaired, and well suited for moving earth, when the length of haul is limited to a few rods. Drag-scrapers are made of three sizes, the smallest, for one, and the largest, for two horses.

The wheeled scraper differs from the drag-scraper in having the scoop mounted on wheels. This greatly reduces the tractive force

necessary to convey the load to the dump, and enables the team to do much more work in a given time. The loading and unloading process in the improved wheeled scraper is executed by means of levers, while the team is in motion. Several sizes of wheeled scrapers are made by different firms. They vary in capacity from nine to sixteen cubic feet, and weigh from 300 to 700 pounds. Road-scrapers are almost indispensable, where a large quantity of earth is to be moved. No recent invention has done more toward cheapening the cost of road-grading than the scraper. It should always be at hand, on all highways, whenever any earth is to be moved.

ROAD-MACHINES. — Road-machines are recent inventions, devised for the purpose of excavating earth, transporting it, and dumping it, where needed. Several varieties of these machines have been placed upon the market in the last few years. They are all made upon the same general plan, differing only in detail of construction.



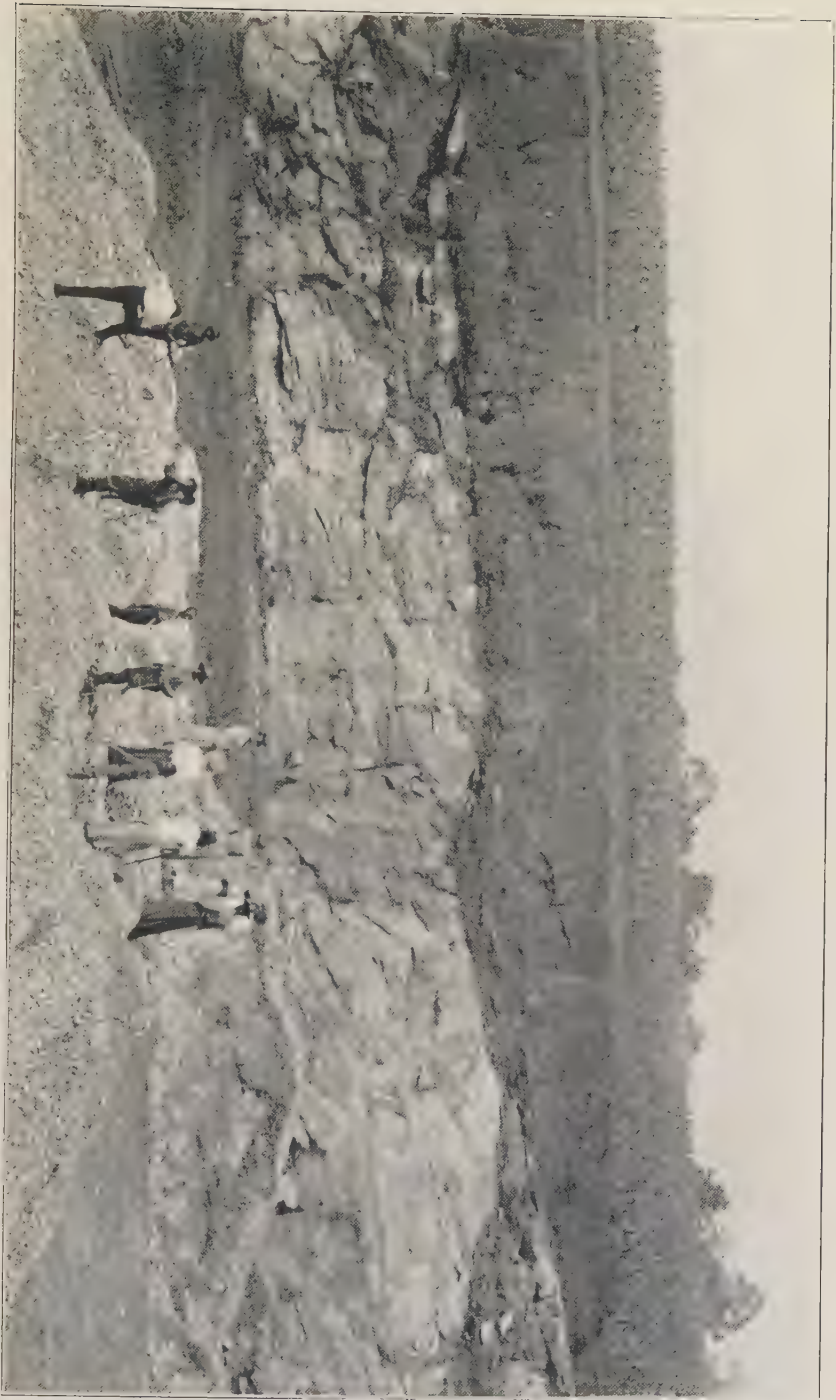
A Drag Scraper.

They consist of a large iron or steel scraper, mounted on wheels, so attached to a suspended frame as to be easily adjusted at any desired angle, by the movement of certain levers. A road-machine, to give satisfaction for general use, should be of light draft, well constructed of good material, easily and safely operated, and readily adjusted for all kinds of road-work. Mr. Isaac Potter, in speaking of the merits of road-machines, says :¹ "A good road-machine will do the work of twenty laborers ; and when put to its best will do the work of forty. * * * * * To the fair-minded, intelligent road official of the present day, there is no question as to the many advantages of road machinery over any other method of repairing dirt roads. Besides doing the work at

¹ Country Roads, pp. 30-34.

THE ROADS AND ROAD-BUILDING MATERIALS OF GEORGIA

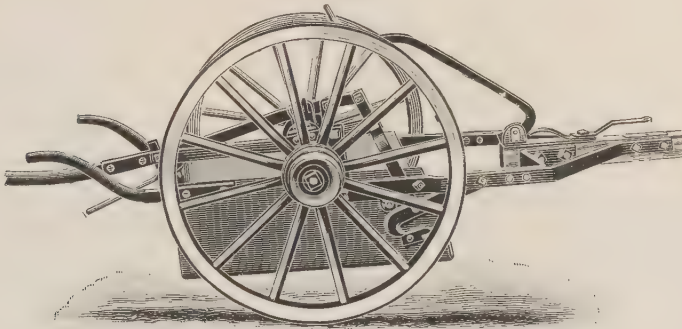
PLATE X



VIEW OF A ROCK QUARRY, NEAR ATLANTA, GEORGIA, SHOWING CONVICTS BREAKING ROCK FOR ROAD MATERIAL.

less than half the cost, vastly better results are obtained. The difference between the result obtained by the use of a road-machine and the old-fashioned plow and shovel method is clearly defined. A road-machine of recognized merit will plow an even ditch of uniform depth, and will plow, where, an ordinary plow will not enter the soil. The scraping blade of the machine moves the earth from the ditch to the middle of the road, distributing it evenly and leaving the roadbed smooth, without any of those little

Fig. 21



A Wheeled Scraper.

lumps and holes which characterize a road repaired in the old-fashioned manner.

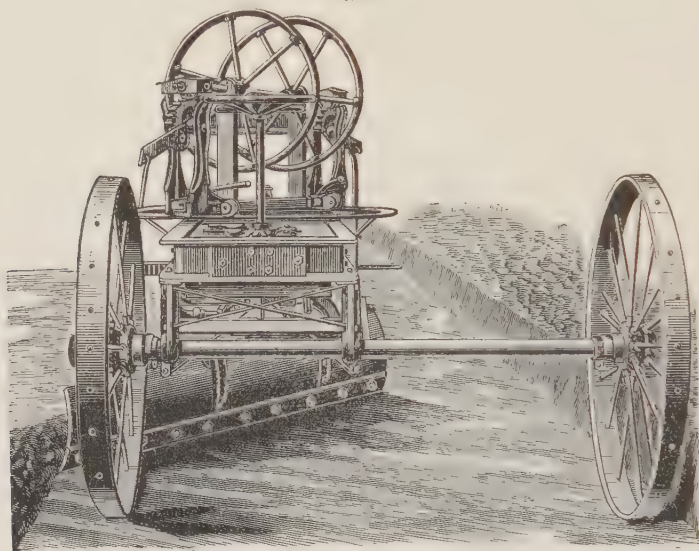
“A good reversible road-machine with two or three teams and two men will repair from three-quarters of a mile to a mile of road a day, depending of course on the width of road and the amount of earth to be moved. A conservative estimate shows, that to do the same work in the old-fashioned way will require a plow, two teams, and at least forty men. * * * * *

“Anyone, who has compared the road built by the old-fashioned method with its rough, uneven surface, with the clean ditches and smooth and even surface of a road built by the machine method by a good operator, will not hesitate long in passing judgment on the two methods. A road-machine can also be made very useful

in the work of under drainage, where side drainage is considered incomplete".

In addition to the above described machine, there is another, called the "New Era" grader, which is constructed on a somewhat different plan. This machine not only excavates the earth; but it also automatically carries the earth some distance, on an end-

Fig. 22



Champion Road-Machine.

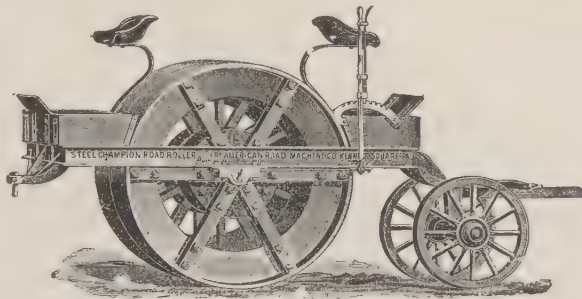
less belt, and dumps it into the center of the road or loads it on wagons. The earth is excavated by means of a large plow. This class of machine is rather complicated; and it will probably never come into general use on ordinary country-roads.

ROAD-ROLLERS.—There are two types of road-rollers in common use, one known as the horse-roller, and the other, as the steam-roller. The horse-roller, which weighs from two and a half to eight tons, is usually constructed in two sections, each revolving on an independent axis. These sections, in standard rollers, are

about five feet in diameter and twenty-six inches in length, giving a total rolling width of fifty-two inches. The best rollers of this class are reversible, so that the tongue may be changed from one side to the other. They also have ballast-boxes, located on the frame for the reception of pig iron or other heavy material for increasing their weight. Some of these rollers, as the "Addyston Reversible" horse-roller, have solid heads; and their weight is increased by filling the roller-drum with water.

A steam-roller, which is a kind of locomotive mounted on broad wheels, is frequently made much heavier than horse-rollers. They often have a weight of twenty tons; but the average is usually from ten to fifteen tons. It has been found by experience,

Fig. 23



Champion Horse Road-roller.

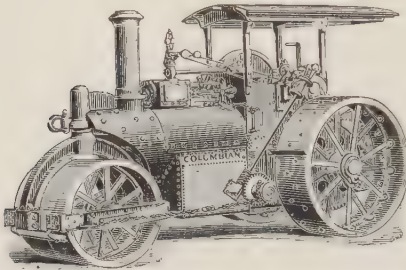
that, if a roller is too heavy, it has a tendency to crush the stones into powder, in the process of consolidating, and to thus injure the wearing quality of the road. Furthermore, the heavy rollers are objectionable, on account of the strain on bridges and culverts.

The lesser the weight of the roller, the greater will be the number of times required to pass over a road, in order to consolidate it. However, it is claimed by most road engineers, that the work is more durable and satisfactory, when done by the lighter rollers. For this reason, many road-constructors advocate the use of the horse-roller, in preference to the steam-roller. Prof. Shaler, in discussing the merits of road-rollers, says:¹ "The advantage of

¹ American Highways, p. 202.

the modern instrument (steam-roller) in all except the purchase price is very great, and the cost of compressing a given amount of stone by it is so much less than that incurred by the use of the ancient instrument (horse-roller) that the price should, in most cases, not be reckoned." It is quite probable, that this statement is true, when applied to the Commonwealth of Massachusetts, where highway improvement has reached an advanced stage. However, through the South, where the majority of our highways are common earth-roads, it is quite likely, that the horse-roller will, for some time to come, answer all practical purposes.

Fig 24



A Steam Road-roller.

There is a great variety of both horse- and steam-rollers on the market, all of which will do satisfactory work, when properly managed.

ROCK-CRUSHERS. — Probably the most important of all modern additions to the list of road-making machinery is the rock-crusher. This machine has, in the last few years, so lessened the cost of preparing stones for macadamized roads, that this class of highways has been brought within the reach of many rural districts. There is quite a number of different makes of rock-crushers now on the market, the most of which are constructed on the plan of the original Blake stone-crusher,¹ thus described by Gen. Q. A. Gillmore:² MM "is a frame of cast-iron in one piece, which supports the other parts. It consists of two parallel cheeks, shaded dark in the drawing, connected together by the posts AA. B represents a fly-wheel, working on a shaft, having its bearings at D, and formed into a crank between the bearings. It carries a pulley C, which receives a belt from a steam-engine. F is a rod or pitman, connecting the crank with the toggles GG. The end

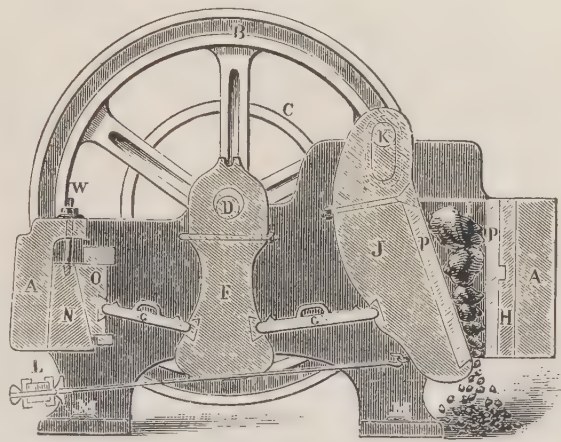
¹ See fig. 25.

² Roads, Streets and Pavements, by Q. A. Gillmore, p. 92.

of the frame A, on the right of the figure, supports a fixed jaw H, against which the stone is crushed. J is a movable jaw pivoted at K. L is a spring of India rubber, which being compressed at each forward movement of the jaw J, aids its return. Every revolution of the crank causes the pitman F to rise and fall, and the movable jaw to advance a short distance toward the fixed jaw and return, so that a stone, dropped in between the jaws J and K, will be broken at the next succeeding bite. The fragment will then fall lower down

and be broken again and again at each succeeding revolution, until it passes out at the bottom of the opening between the jaws. The jaws may be set, so as to deliver any desired size of stone by suitably adjusting the wedge N, inserted against

Fig. 25



The Blake Patent Stone-breaker.

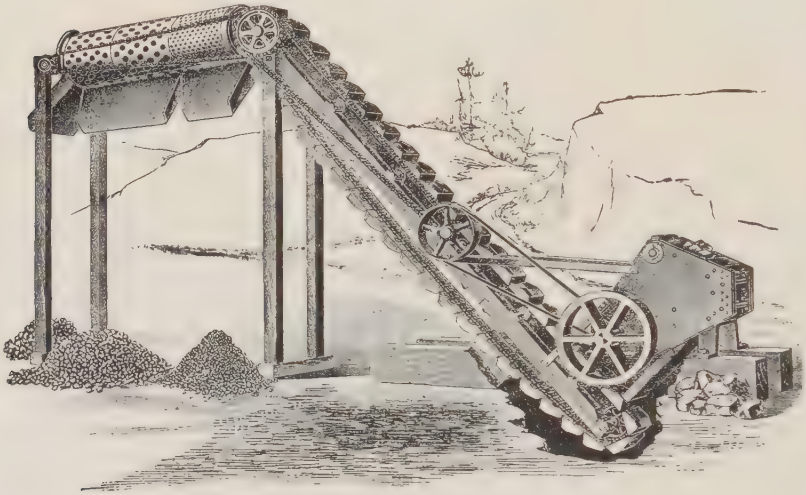
the toggle-block O. The majority of crushers are supplied with a revolving screen, which sorts the stones into different sizes as they pass from the crusher, and drops them into bins, from which they can be easily loaded into wagons. Stone crushers are divided into two classes, namely, the stationary and the portable crusher. The latter can be easily moved from place to place, and is most suitable for general purposes. Especially is this true, where stone can be had at a number of places along the roadway."

Mr. Isaac B. Potter, in his work entitled "Macadam Roads", gives the following excellent advice on the selection of a rock-crusher: — ^I

^I Page 48.

“Certain prominent facts should control the purchaser, to enable him to obtain such a machine, and to operate it in such a manner, as will tend to the production of good work at a minimum price. It is generally understood, that, from the nature of the work required, a stone-crusher in its working parts exerts prodigious powers; but the fact is too often forgotten, that all machinery is perishable, and that an overworked crusher, like an overworked man, is likely to break down in the midst of an important task.

Fig. 26



Champion Rock-crusher with Elevator and Screen Attached.

All reputable manufacturers supply machines, in which the parts subjected to the greatest strain and wear are of hardened and tempered steel, and such machines, if fairly treated, will give good results and good satisfaction to the buyer. To obtain the best results from any crusher, it should be regularly and constantly “fed”, while in operation, and have its wearing parts renewed, whenever they break or show signs of excessive wear; and it should, moreover, be run by power somewhat in excess of that actually required. This matter of power is an important one, and one, in which

apparent *cheapness* is the poorest economy. If, for example, an engine of eight horse-power is just sufficient to run a crusher of a given capacity, the work will be done and the crusher operated with varying speed and with a jerky motion; while an engine of twelve horse-power will do the work with an ease and uniformity of motion, which always proves the existence of reserve power, saves the machinery, and renders more satisfactory results. When we consider, in addition to these facts, that the smaller engine costs about \$500, and the larger one, only about \$140 more (price-list), the extra expense should offer no barrier to the purchase of the larger engine.

"In the selection of a stone-crusher and engine for use in an ordinary country town, a machine capable of producing from two to twenty tons of broken stone per hour will generally answer; and to run such a machine, it is best to select an engine of ample size and to consult the manufacturers, before making the purchase. Roughly, it may be estimated, that such a machine will cost from \$700 to \$1,200; and the cost of an engine, to run it, will vary from \$500 to \$1,000, according to the make and quality. These figures are intended to serve as a mere approximation."

The following tables, from Potter's "Macadam Roads",¹ give the regular published information, concerning some of the leading stone-crushers:—

The Gates Crusher (Chicago, Ill.)

Size	Weight— Pounds	Capacity— Tons per Hour	Horse-Power Required	Price
0	3,100	2 to 4	4	\$ 400
1	5,500	4 to 8	8	600
2	7,800	6 to 12	12 to 15	800
3	13,500	10 to 20	20 to 30	1,200
4	20,000	15 to 30	30 to 40	1,900
5	27,000	25 to 40	40 to 50	2,500
6	36,000	30 to 60	50 to 60	3,500
8	89,000	100 to 150	125 to 150	7,000

¹ Page 55.

The Farrell & Marsden Crusher (Ansonia, Conn.)

No.	Receiving Capacity	Approximate Product of 2-inch Stone per Hour	Approximate Weight	Horse-Power	Price
3	10 by 4 in.	3 cubic yds.	4,900 lbs.	6	\$ 275
4	10 by 7 in.	5 cubic yds.	7,800 lbs.	12	500
5	15 by 9 in.	8 cubic yds.	14,800 lbs.	15	750
6	15 by 10 in.	9 cubic yds.	15,000 lbs.	15	800
8	20 by 10 in.	10 cubic yds.	17,000 lbs.	20	1,050

The Brennan Crusher (New York City)

No	Receiving Capacity	Approximate Product of 2-in. Stone Per Hour	Approximate Weight	Horse-Power
1	14 by 48 in.	40 cubic yds.	50,000 lbs.	50
2	12 " 37 "	25 " "	32,000 "	40
3	10 " 25 "	15 " "	16,000 "	30
4	8 " 25 "	12 " "	13,000 "	20
5	7 " 20 "	9 " "	10,000 "	15
6	8 " 20 "	4 " "	7,000 "	8

The Champion Crusher (Kennett Square, Pa.)

No	Receiving Capacity	Approximate Product of 2-inch Stone per Hour	Approximate Weight	Speed	Driving Pulleys Diameter and Face	Horse-Power
3	7 by 13 in.	10 to 15 tons	5,000	180 rev.	44" by 8"	10
4	9 " 15 "	12 " 18 "	8,000	160 "	44 " 8	12

TIRES.—There has been much discussion throughout the United States in the last few years, on the question of wagon-tires; and in some States, notably New York and Michigan, laws have been enacted bearing upon this question. Many of the European countries have laws fixing the minimum width of wagon-tires; and it seems now to be only a question of time, when such a law will become universal in this country. The numerous experiments, which have been carried on in the last few years, thoroughly



EXPOSURE OF A TRAP DIKE ON THE CENTRAL OF GEORGIA RAILWAY, 4 MILES EAST OF NEWNAN, COWETA COUNTY, GEORGIA.

demonstrate the great advantage of wide tires over narrow tires. Several of these experiments taken from Circular No. 31, U. S. Department of Road Inquiry, are here given :—

“Onondaga County, New York, furnishes an interesting illustration of the value of wide tires as road-rollers. The Solvay Process Company, of Geddis, in that county, was accustomed to hauling heavy loads of stone, for four and a half miles from the quarry. To test the wide-tire theory, they built several wagons having 4-inch tires on the front wheels and 6-inch tires on the rear wheels, and with the rear axles longer than the others, so that the track of the rear wheels would just lap outside of those made by the others. The result of the use of these wagons was to produce a hard, smooth, compact surface; and the road, having been filled, so as to raise the middle, or “crown” it, is thoroughly drained at the surface, and always fit for use with the heaviest loads. Loads of 8 tons are frequently hauled over them, and instead of tending to cut up the road, serve to roll it harder and harder. The superintendent reports, too, that the improved condition of the road has reduced the cost of hauling the stone from 80 cents per ton to 60 cents, or 25 per cent.

“It has also been proven by experiments upon a number of occasions, that the use of wide tires considerably reduces the amount of power required to move loaded wagons. One of these tests was made by the officers of the U. S. Department of Agriculture at the Atlanta Exposition in 1895. Two wagons, both weighing alike with their loads, were drawn over a wet piece of clay road, one wagon having 2-inch tires, the other, with 4-inch tires and with the rear wheels farther apart, than the front wheels, so as not to run in the same track. It was found by the use of the tractometer, an instrument made to register the power exerted, that twice as much pull was required to haul the 2-inch tired wagon as was required for the other. That part of the road traversed by the narrow-tired wagon was cut and rutted to a depth of several inches, while the tires of the other wagon had rolled the road into a smooth and hard surface.

"The Missouri Agricultural Experiment Station made a series of tests, extending from January, 1896, to September, 1897, in order to thoroughly and scientifically ascertain the value of wide tires as compared with narrow ones. They were made with two wagons, one with 6-inch tires, the other with standard $1\frac{1}{2}$ -inch tires, both wagons of the same weight, and each loaded with 2,000 pounds. It was found that the same power needed to draw the narrow-tired wagon, with its 2,000-pound load, on a gravel road, would have pulled a load of 2,482 pounds on the wide-tired wagon. The same power, required to draw the 2,000-pound load, on narrow tires, over dirt and gravel roads, when these were dry and hard, was found sufficient to draw a 2,530-pound load on the wide-tired wagon under the same conditions; and it was shown, that, when these roads were deep with mud, but partly dried at the surface by a few hours' sun, the same power, required to draw the 2,000-pound load over them, on the narrow tires, would pull a load of 3,200 pounds on the wide tires. Director Waters, of the Station, states, that the conditions, under which the narrow tires offer an advantage over the wide ones, are 'unusual, and of short duration,' and that, 'through a majority of days in the year, and at times, when the dirt roads are most used, and when their use is most imperative, the broad-tired wagon will pull materially lighter than the narrow-tired wagons.' He states, that 'a large number of tests on meadows, pastures, stubble land, corn ground, and plowed ground, in every condition, from dry, hard and firm to very wet and soft, show, without a single exception, a large difference in draft in favor of the broad tires. This difference ranged from 17 to 120 per cent.' As a result of all experiments conducted, he says: 'It appears, that six inches is the best width of tire, for a combination farm and road wagon, and that both axles should be the same length, so that the front and hind wheels will run in the same track.'

"Experiments made at the Agricultural Experiment Station in Utah have demonstrated, that a $1\frac{1}{2}$ -inch tired wagon drew about 40 per cent. heavier, than one with 3-inch tires, and weighing,

with its load, the same as the other. At the Ohio State University, it was shown, that a wagon with 3-inch tires and loaded with 4,480 pounds, could easily be hauled by two horses over an ordinary dirt road in good condition and with a hard surface; while, with a narrow tire, half as much was a full load for a double team."

In view of these various experiments, all of which demonstrate conclusively the special merits of the wide tire, there should no longer be any doubt, as to which kind of tire to adopt for common earth-roads.

CHAPTER VII

THE TOPOGRAPHY OF GEORGIA IN ITS RELATION TO THE HIGHWAYS

The cost of building and maintaining highways depends, in a great measure, upon the topography of the country, through which they pass. If the country is level, little or no expense is incurred in grading; while, on the other hand, if the country is mountainous, the chief cost of road-construction is chargeable to this account. High mountains and precipitous ridges often become such obstacles in the way of road-building, that no intercourse or traffic is carried on, between the inhabitants of adjacent valleys, although they may lie only a few miles apart. Frequently, swamps and morasses also are, in like manner, difficult barriers to the way of free communication between localities having a common interest.

In discussing the topographic features of Georgia with reference to highway-construction, it is thought advisable to divide the State into three divisions, namely, the Paleozoic area, the Crystalline area and the Tertiary area. The last embraces both the Tertiary and the Cretaceous deposits of the State. Each of these divisions is named from the geological formation of its respective area, which has given rise to certain well-marked topographic features. The smallest of these divisions is the Paleozoic, lying in the north-western part of the State. It comprises an area of about 3,500 square miles, and includes the greater part of ten counties, all of which are well adapted to agricultural purposes. The rocks of the Paleozoic area consist of limestone, shale and sandstone, originally horizontal, but now compressed into gentle folds having a northeast-and-southwest trend. In places, these folds have been so closely pressed, that the strata have been broken and re-

lieved by huge faults, some of which show a total displacement of several hundred feet. This characteristic structural geology of the region explains, in a great measure, the striking topographical features of the area. Its present configuration is due almost solely to surface erosion; but this, in turn, has been conditioned largely by the original folding and faulting of the strata, together with the relative position of the hard and soft rocks.

Dr. C. W. Hayes, of the U. S. Geological Survey, in describing this area, divides it topographically into three divisions: (1) plateaus; (2) sharp edges; (3) undulating or level valleys.

The plateaus are confined to the western part of the area, and include Lookout and Pigeon mountains and a portion of Sand mountain. These plateaus, which have nearly a level surface, are elevated from 2,000 to 2,400 feet above the sea, and terminate in precipitous escarpments rising a thousand feet or more above the adjacent valleys. Owing to the steepness of these escarpments, it is a very difficult matter to construct a road with easy grades, from the valleys to the plateaus; but, when the elevated areas are once reached, the evenness of the surface reduces the cost of construction to a minimum. As the plateaus are nowhere intersected by streams, they form barriers, affecting, more or less, free intercommunication between the adjacent valleys.

The second type of surface, which is confined to the eastern part of the area, consists of a number of sharp parallel ridges, having a northeast-and-southwest trend. The ridges are due to the slow weathering of the upturned edges of hard sandstone, which, in the plateau, lies almost horizontal. The smaller of the ridges are frequently intersected by streams, along which cross-country roads, of easy grade, can be constructed. The main thoroughfares are located in the narrow valleys, where no serious obstruction is presented to road-construction.

The undulating-valley type of surface lies between the plateau on the west, and the sharp ridges on the east. It consists of low, wide, comparatively level valleys, drained by deep, sluggish

streams. The famous Chickamauga National Park is located in one of these typical valleys. Owing to the comparatively level surface of the valleys, this division of the Paleozoic area presents fewer difficulties to highway-construction, than either of the other divisions. Cross-country roads can here be built with but little cost; as the intervening ridges are low and can be ascended on easy grades.

In considering the Paleozoic area as a whole with reference to highway-construction, it may be stated, that the topographic features of the region offer, as a rule, no very marked difficulties to highway engineering, so long as the roads have a northeasterly and southwesterly direction; but, on the other hand, when they traverse the country at right angles to this direction, the grading is likely to be heavy. This is especially true, in crossing the main parallel ridges.

THE CRYSTALLINE AREA.—The Crystalline area is divided topographically into two distinct divisions: (1) the mountainous region, (2) the plateau region. The former division comprises several counties in the northern part of the State, east of the Paleozoic area, which are very mountainous. Many of the higher peaks reach an elevation of more than 4,000 feet above sea-level. The valleys of this region are narrow, and the streams are generally quite rapid. The ridges have a general northeast-and-southwest trend; but there are also many cross-ridges, which give to the surface of the section a very rugged and picturesque appearance.

The underlying rocks are chiefly contorted mica-schists, gneisses and slates, whose uneven weathering has had much to do with shaping the topography of the region. Road-building in this mountainous part of the State is both difficult and expensive; and, as a consequence, the highways are generally in bad condition for traffic. The valley roads are sometimes in fair condition; but even these often have steep grades and are difficult to maintain, on account of the frequent overflow of streams.

The plateau region of the Crystalline area embraces all that part

of the State, lying north of an irregular line, connecting Augusta, Macon and Columbus, with the exception of the Paleozoic area and the mountainous region of the Crystalline area, just described. This portion of the State, known as the Piedmont plateau, is the southern extension of a wide and fertile undulating plain traversing the Carolinas and Virginia. It is the remnant of an old worn-down mountain range, whose peaks and ridges once towered several thousand feet above the present land surface, and probably reached, in places, the height of perpetual snow. A few fragments of this elevated region are still to be seen, as isolated peaks, widely distributed over the plateau. Some of the most noted of these lonely sentinels in Georgia are Kennesaw, Stone and Graves mountains, which owe their elevations almost entirely to the superior hardness of the rock, of which they are formed. The Piedmont belt in Georgia has an elevation varying from 500 to 1,500 feet above sea-level. It slopes gradually to the southeast, and is crossed by numerous streams flowing in winding valleys from 100 to 250 feet below the surface of the upland plains. When viewed from an elevated point, the plateau has all the appearance of a level plain; but in traversing it the seeming plain is found to have an undulating or rolling surface. Low, broad ridges, forming water-sheds between the main streams, are more or less common, and often extend for many miles without a break or interruption. Along such ridges and their adjacent valleys, highway-construction is comparatively easy. The grade from the valleys to the ridges is often considerable in a direct line; but, by a sinuous or zig-zag route, the elevation can generally be attained by a comparatively small cost in grading. The underlying granites, gneisses and mica-schists of the Piedmont belt are generally decomposed on the hills and ridges to considerable depths, so that the actual cost of grading is reduced to a minimum. Material, of good quality for macadamizing purposes, is abundant throughout the entire area.

THE TERTIARY AREA. — The Tertiary area, comprising all the Coastal Plain, lies south of the Crystalline area, and embraces

more than half of the entire State. It is, generally speaking, a comparatively level plain sloping generally to the south. Many streams traversing this area are of large size. They have cut broad, shallow valleys along their courses from 50 to 150 feet below the surrounding country. Ravines and small gorges are common along the shallow valleys, where tributaries join the main stream. The adjacent uplands, in the immediate vicinity of the valleys, are also often carved into rounded hills, which give rise to distinct topographic features resembling very closely the surface configuration of the more northern Crystalline area. The valley and hill features of the region become less pronounced toward the south, where the surface becomes remarkably level. There are a few localities even in the extreme southern part of the State, and notably in the vicinity of Thomasville and Whigham, where the surface is quite undulating and much broken. Such areas, however, are of limited extent; and they soon give place to wide stretches of piney woods, which are occasionally interrupted by cypress swamps, old sloughs, lime-sinks and lakes. Low sandhills are of frequent occurrence in the Tertiary area; but they are usually of limited extent and are confined mostly to the vicinity of the coast or near the larger streams. These sand dunes become conspicuous features of the landscape in the vicinity of Butler, Albany and Bainbridge, where they form hills fifty feet or more in height. Along the coast, they become quite prominent in Camden, Glynn and Wayne counties. In the latter county, they are crossed by the Southern Railway near Pendarvis P. O.

The northern part of the Coastal Plain, where it comes in contact with the Crystalline area, has an elevation of from 250 to 800 feet above the tide-water. It here shows a more advanced stage of denudation than the part of the plain further south, and is divided into many broad, elevated strips by shallow valleys. These elevations have the appearance of low, very broad ridges, which seem to be the eroded portion of a once nearly horizontal plateau. Near the coast, the surface becomes less deeply dissected by running streams, which is evidently due to its more recent ele-

vation from the sea. The streams in their lower stretches traverse low palmetto lands or swamps, which they flood during the rainy season, making them both dangerous and difficult to cross.

An examination of a profile of any of the several railroads traversing the coastal plain shows, that the region is remarkably level. This is exceptionally true near the coast, where the railroad frequently runs many miles in almost an air-line, with a total grade of only a few feet.

The topography of the Tertiary area or the Coastal Plain is very favorable for highway-construction. The most serious difficulties in the way of road-building are the numerous swamps and the low depressions along the larger river valleys, where the roadway has to be elevated, in order to insure proper drainage. Grading, throughout the entire area, is reduced to a minimum, by reason of the flatness of the country; yet, there is usually sufficient variation in the surface to carry off all surface water.

CHAPTER VIII

THE ROAD-BUILDING MATERIALS OF GEORGIA

The road-building materials of Georgia are quite abundant, and pretty evenly distributed throughout the State. Nearly all the varieties of stone used in highway-construction occur in large quantities in many sections. It is questionable, whether any State in the Union possesses a greater variety of road-building materials than the State of Georgia. In describing these materials, the State will be divided into three divisions, namely, the Paleozoic, the Crystalline and the Tertiary areas, corresponding to the three topographic divisions of the State, previously described.

ROAD MATERIALS OF THE PALEOZOIC AREA

The materials used for road-construction in this part of the State, which comprises all or part of the ten counties, Polk, Floyd, Bartow, Gordon, Murray, Whitfield, Catoosa, Chattooga, Walker and Dade, consist of limestones, cherts, shales and sandstones.

Limestone.—The limestones of the area are very abundant, and are well suited for macadamizing purposes. They are all of Silurian age, and are divided geologically into three divisions, (1) The Knox Dolomite, (2) The Chickamauga Limestone, and (3) The Bangor or Mountain Limestone.

The Knox Dolomite is the most extensive of the three calcareous formations. It attains a thickness, in places, of more than 3,000 feet, and occurs in the form of a number of broad and narrow bands, traversing the area in a northeast-and-southwest direction, giving rise usually to broad, rounded ridges. The formation consists largely of compact, heavy-bedded, light-gray magnesian limestone, often oölitic and always containing a considerable

amount of siliceous material, in the form of chert, hereafter to be described. The silica present is in the form of flinty or cherty concretions, unevenly distributed throughout the various beds. These concretions sometimes occur in such abundance, as to form well-defined layers, two feet or more in thickness. When the dolomite weathers, the flinty or cherty material remains with the residual clay, forming a mantle, often many feet in thickness. Where the siliceous material is not abundant, the weathered product is usually a very tough, red, tenacious clay, which forms a very unsatisfactory roadbed during wet weather. The Knox dolomite has been used to a limited extent throughout the Paleozoic area for road macadam; but its most extensive use, up to the present, has been for constructing retaining-walls, bridge-piers and culverts. It has also been much used in places, notably Graysville and near Cartersville, for making lime. The uniform texture and the semi-crystalline structure of the dolomite well suit it for macadamizing purposes. It would indeed be a difficult matter to find a calcareous deposit better adapted for road-material than some of the beds of this formation. The stone is easily quarried, and is readily crushed by the rock-breaker; but it has, at the same time, sufficient toughness, to form a durable wearing-surface. Its binding-quality is all, that could be desired for a first-class road-material.

The Chickamauga Limestone overlies the Knox Dolomite. It occurs in the form of narrow bands, more or less parallel, and often valley-forming. The formation is so-called from Chickamauga valley, where it reaches its greatest development. Its various beds differ considerably, both in physical structure and mineral composition. Dr. C. W. Hayes, of the U. S. Geological Survey, in describing the formation says:—¹

“It is, in its western exposure, a blue, flaggy, highly fossiliferous limestone, with some local variations of minor importance. From the eastern edge of Lookout mountain, there is a gradual and uniform change toward the southeast. The change consists in a decrease in the abundance of fossils and calcareous material

¹ Bulletin No. 4, Geological Survey of Alabama, p. 42.

and an increase in argillaceous matter. The limestone becomes more earthy and along the eastern edge of the area is red or dove-colored and sparingly fossiliferous."

In the vicinity of Rockmart, the Chickamauga formation becomes highly argillaceous and forms a good quality of roofing slate. Another peculiar feature of this formation is the heavy beds of breccia formed of angular fragments of chert occurring in the ridges south of Rockmart. This is pointed out by Dr. Spencer, as showing a local unconformity at the close of the Knox Dolomite epoch.¹ Much of the Chickamauga limestone weathers into a shale, having a knotty structure. Such material is often used for road-surfacing, without being crushed; but its wear, on account of its fragile nature, is usually unsatisfactory. The compact, blue variety of this stone, on the other hand, makes an excellent macadam. It has been extensively used for this purpose, both in Chattanooga and in Chickamauga Park. The City Engineer of Chattanooga, in speaking of this material, says: "I regard this stone superior to any material so far tried on our streets for macadamizing purposes. It binds well, is comparatively free from dust, and makes a hard, smooth road-surface." The Chickamauga limestone varies from 1,000 to 1,800 feet in thickness, and is the underlying rock in many of the narrow, fertile valleys of Northwest Georgia. In weathering, it forms a deep clay soil usually difficult to drain; and it makes a very unsatisfactory road-surface in wet weather.

The Bangor or Mountain Limestone, which is of Carboniferous Age, is a pure, dove-colored limestone, attaining a thickness of about 900 feet. It is highly fossiliferous, and contains, in places, crinoid stems in great abundance. The formation is well exposed along the flanks of Pigeon and Lookout mountains, where it outcrops beneath the sandstones. The extent of the area covered by this formation is limited mainly to the narrow belts at the base of the above named mountains; and, as a consequence, it will probably never become of very great importance in road-construction.

¹ The Paleozoic Group of Georgia, by J. W. Spencer; 1893; p. 85.

However, its use for macadam in the vicinity of Chattanooga shows, that it is well suited for that purpose.

Chert.—The chert deposits of the Paleozoic area are quite extensive, and are widely distributed throughout the area. They occur in two different geological formations, namely, the Knox Dolomite and the Fort Payne Chert, the latter formation being the lowest member of the Carboniferous formation. The chert of the Knox Dolomite is co-extensive with the dolomite itself, and is by far the more important deposit of the two, both from a geological and an economic standpoint. It occurs, as previously stated, in the dolomite in the form of nodules; and also in beds, frequently several feet in thickness. In the weathering of the dolomite, the chert remains as a residual product, in the form of gray flinty nodules. This siliceous material frequently accumulates to the depth of many feet, along the sides and slopes of ridges, where it is often well exposed in railroad cuts. The chert of the Knox Dolomite is an impure variety of flint, frequently containing more or less calcareous material, and is readily crushed into sharp, angular fragments. It has been extensively used for several years for surfacing roads and streets, throughout North Georgia and Tennessee. The material is well suited, for roads of light travel; but, where the traffic is heavy, it is inferior to limestone. It possesses an excellent binding-quality; but, after long drought and much travel, it becomes somewhat dusty. In cities, this difficulty can be readily overcome by sprinkling, which causes the loose particles to unite into a solid bond, forming a compact, smooth, dustless drive-way. The cheapness, with which this material can be prepared, together with its admirable binding-qualities, makes it one of the most important road-surfacing materials in the State.

The chert is often most favorably located for working and for transportation. The railroads traversing the northwestern part of the State have frequently exposed in their cuts, immense deposits of this material, almost entirely free from clay and other foreign materials. In such favored localities, it can be loaded on flat-cars at a nominal cost and shipped to any part of the State. This ex-

periment has been tried, in the last few years; and, in a few instances, the material has been shipped as far south as Macon, and even to Savannah, where it was used for street-surfacing. With reduced freight-rates, the cherts of the Paleozoic area of North Georgia can be shipped from 100 to 200 miles, and sold at a less price than broken stone. The wide use of this material in the future will no doubt depend, in a great measure, upon freight-rates.

The Fort Payne Chert is a siliceous limestone, varying in thickness from 50 to 200 feet. Its lower layers consist largely of heavy beds of chert, resembling very closely the chert of the Knox Dolomite. This formation, like the Mountain Limestone, occurs along the base of Lookout and Pigeon mountains. It also appears along Taylor's ridge and Horn mountain, further east. The siliceous nature of the formation is well exhibited along the Southern Railway, about one mile south of Sugar Valley Station. The chert here forms a heavy mantle, along the base of a ridge, which, in places, must be many feet in thickness. Some distance up the side of the slope is to be seen, in an excavation recently made for road-material, the natural outcropping of heavy beds of chert. The surfaces of the different layers are usually very rough, being full of irregular cavities, which are evidently due to the weathering of the calcareous material formerly filling these spaces. The chert of the Fort Payne formation is usually distinguished from the Knox Dolomite cherts by its numerous fossils. It is, in places, very fossiliferous, being made up largely of the stems of crinoids, which are cemented together by a siliceous matrix. The siliceous material of these two formations apparently possesses about equal merits for road-surfacing. However, the wide extent and the abundance of the Knox Dolomite makes it far more important as a road-building material.

Shale.—The shales of the Paleozoic area belong to the Cambrian and Carboniferous formations. Those, deposited during the Cambrian period, have been divided by Hayes into three divisions,¹ (1) the Apison Shale, (2) the Rome Formation, and (3)

¹ Geological Atlas, U. S. Geol. Surv., Ringgold Folio (Ga.), p. 2.

the Connesauga Shale. These shales are generally valley-forming, and are commonly bounded on either side by Knox Dolomite ridges. Chattooga, Peavine and Dogwood valleys are all underlain by Cambrian shales. The aggregate thickness of these shales is probably not less than 6,000 feet. The different divisions vary considerably in color, mineral composition and physical structure. The Apison shale is frequently sandy, and always banded with brilliant colors of red, purple and yellow. The Rome formation is scarcely less brilliantly colored; but it is far more siliceous, some of its beds consisting of an almost pure white quartzite, while the Connesauga shale is distinctly calcareous and, in places, passes into an oölitic limestone.

The Floyd shale, which is of Carboniferous age, is well developed in Floyd county immediately west of Rome. The formation consists of calcareous shales with beds of sandstone and limestone. The sandstone, when abundant, gives rise to low ridges as in Texas and Dirt Town valleys.

The shales of the Paleozoic area are of but little economic importance, as road-building materials. However, the shales in the vicinity of Rome have been used to a considerable extent for road-surfacing. This material makes a fair road surface; but it is objectionable, on account of its rapid wear, and dusty condition during the dry season, especially when there is much travel.

Siliceous Gravel, which results from the weathering of the shales, often occurs in considerable abundance along the small streams traversing the shale valleys. This material has also been used to a limited extent for road-surfacing in the vicinity of Rome. It wears fairly well, and makes a more durable and dustless road-covering than the shale itself.

The Limestones and Quartzites of the shales are suitable for road-metal; but their limited quantity practically prohibits them, from ever becoming more than of local importance.

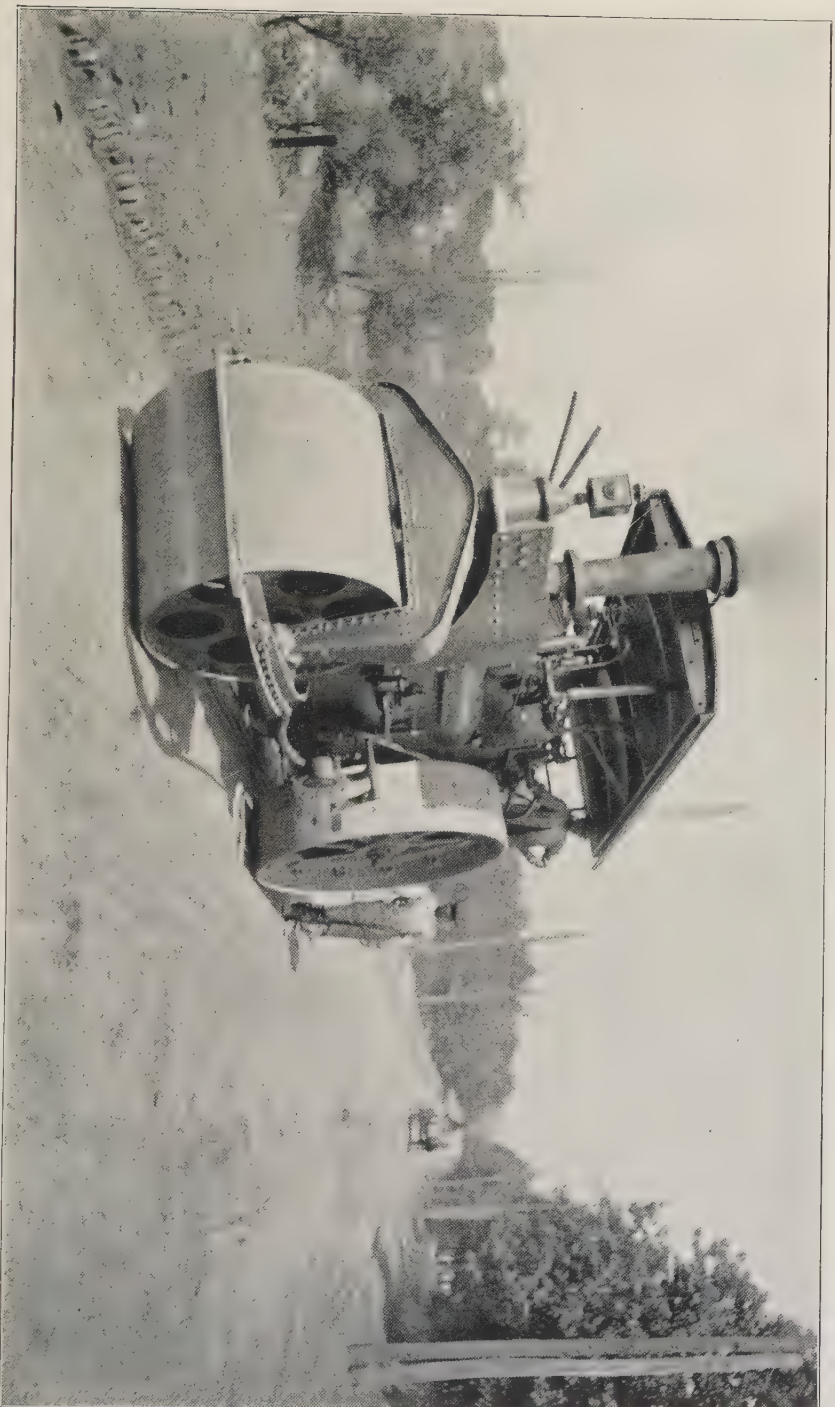
Sandstone.—The sandstones of the Paleozoic area are confined chiefly to Pigeon, Sand and Lookout mountains. They have been divided into two divisions, namely, the Walden's Ridge sand-

stones and the Lookout Mountain sandstones. The former constitute the surface-rock of the above named mountains; while the latter form the cliff and escarpments along their slopes. The two formations are somewhat similar in character. Each consists of sandstone and conglomerate, interstratified with beds of shale. The aggregate thickness of the formations is several hundred feet. These sandstones are easily crushed; and consequently they are of but little value for road-metal. The *conglomerate*, associated with the sandstone, forms beds of rounded gravel when weathered, which is often fairly well suited for surfacing roadways.

THE ROAD-BUILDING MATERIALS OF THE CRYSTALLINE BELT

The road-building materials of the Crystalline area consist of granite, gneiss, diorite, schists, quartzite, marble, massive quartz and trap rock.

Granite. — The granite is very generally distributed throughout the Crystalline area, where it occurs in the form of large intrusive masses in the gneisses and schists. These granitic masses often cover hundreds of acres, and occasionally, as in the case of Stone Mountain, form dome-shaped masses, having an elevation of several hundred feet above the surrounding country. Both the muscovite and the biotite varieties of granite occur in the Crystalline area; but the latter is much more abundant. In texture, these granites differ widely. They vary from an exceedingly fine-grained, homogeneous, monumental stone to a very coarse-grained granite or pegmatite. The fine-grained varieties are quite extensively quarried at several localities in the State for building and monumental stone; and also for street-paving purposes. The physical tests, which have been made on these granites, show that they have great strength, and are therefore among the best of this class of stone for road-material. However, it is not likely, that they will ever become of general use for road-surfacing, where there is such an abundance of other materials of superior quality.



STEAM ROLLER AT WORK ON BATTLE HILL AVENUE, A SHORT DISTANCE BEYOND THE LIMITS OF ATLANTA.

Gneiss. — Gneiss is far more abundant in the Crystalline area than granite; and, as a general rule, it is much more suitable for road-material. The gneisses are divided mineralogically into two well-known varieties, namely, the true gneiss made up of quartz, feldspar and mica, and the hornblende-gneiss, which contains, in addition to these minerals, hornblende as an essential constituent. *Hornblende-gneiss* is generally superior to the true gneiss for road purposes, on account of its finer texture and greater toughness. It occurs, in places, throughout North Georgia, where it is found in narrow belts underlying the so-called red lands. The great amount of iron, which the rock carries, adds greatly to its binding quality. This class of stone has been used to a limited extent on the streets of Atlanta for macadamizing purposes. It wears well and is usually free from dust. The *true gneiss* makes a fair road-surfacing material, when it is fine-grained and composed largely of quartz. Nevertheless, owing to the small amount of iron present, its binding property is always inferior to that of the hornblende-gneiss.

Diorite. — Diorite, which is more or less abundant throughout North Georgia, is a green or dark-gray rock resembling very closely in general appearance both the hornblende-gneiss and the hornblende-schist. It occurs mostly in the form of narrow belts or zones, intercalated with the gneisses and schists. The essential minerals of diorite are plagioclase and hornblende; but there are almost invariably other minerals present, such as pyrite and magnetite. It is always holocrystalline and usually fine-grained. The most of the diorites in Georgia, so far examined by the writer, have a schistose or laminated structure, which has resulted from pressure in the process of mountain making. This structure, which is shown by microscopic examination to be due to the parallel arrangement of the individual minerals constituting the rock, has a tendency to weaken it along certain lines and thereby injure it for road-macadamizing purposes. The diorites, when fine-grained and not too distinctly laminated, make an admirable road-material, second only to diabase. The toughness, hardness and binding

quality of this stone are all excellent. A large exposure of this rock is to be seen on the Southern Railway, a short distance west of Dallas ; and also at many other places, in the Crystalline area, which will be described in full in speaking of the varieties of stone, suitable for road-material, in the several counties of the State.

Trap or Diabase. — Trap rock is very generally distributed throughout the Crystalline area. It occurs always in the form of dikes, which vary in thickness from a few inches to several rods. These dikes, which have originated from the filling up of fissures by molten matter forced up from below, have a generally north-west-and-southeast trend and a nearly vertical dip. They almost invariably cut the gneisses and the schists at a considerable angle, and rarely ever show any evidence of shearing, or any crust movement since their formation. Geologically speaking, the dikes are all of recent origin. They probably date from the Jura-trias period, and are presumably contemporaneous in origin with the Palisades of the Hudson and the trap dikes of the Connecticut valley. It seems quite likely, that many of these larger dikes furnished surface lava-flows in many places of North Georgia during the Jura-trias period. However, as far as the writer knows at present, there exists nowhere within the Crystalline area any remnant of such surface overflows, by which this statement can be verified. This negative evidence, however, cannot be taken as conclusive ; as such flows might have actually existed during the Jura-trias period, and have since been entirely removed by denudation. Prof. I. C. Russell, in speaking of the trap dikes, says : ¹ "In the greater portion of the area along the Atlantic coast, that was fractured, so as to admit of the upward passage of molten rocks from beneath, extensive and deep erosion has occurred, and only truncated dikes and remnants of igneous sheets remain."

All the larger dikes of Georgia, so far examined, are usually quite uniform in thickness, and frequently extend for many miles with but few interruptions. A good example of the large dikes is to be seen in a cut on the Central Railway, a few miles east of

¹ Volcanoes of North America, p. 44.

Newnan. This dike continues for about 65 miles in a southeasterly direction, through Coweta, Meriwether and Talbot counties, finally disappearing beneath the Columbia sands, about four miles south of Talbotton. In this distance, there occur a number of breaks or interruptions, a mile or more in length, which are due either to an actual discontinuity of the dike, or its burial beneath the residual decay from the including gneisses and schists. Parallel with the main dikes, are usually found one or more small dikes, which may vary from an inch to several feet in thickness. The rock forming the smaller dikes is always fine-grained, resembling very closely the contact edges of the larger dikes. When the dikes become of large size, as in the case of the one traversing Jones and Jasper counties, they frequently form low, well-rounded ridges, whose surfaces are covered with innumerable rounded boulders, varying from a few inches to many feet in diameter. In some instances, the large dikes form cataracts or falls in small streams; but this is not of common occurrence. The best exposures of dikes is to be seen along the several railroads traversing the Crystalline area. Here, they are frequently exposed in cuts, to the depth of twenty feet, or more, and their relation to the gneisses and schists, together with their mode of weathering, can be easily studied. In such artificial excavations, they are frequently more or less numerous. At one point on the Georgia Railroad, near Covington, there are to be seen, in a distance of less than two miles, as many as seven dikes in the various cuts. The smaller of these are so completely disintegrated to the depth of several feet, that their presence is not indicated on the surface, in the cultivated fields.

The rocks forming the trap dikes of Georgia are all typical diabase, consisting of plagioclase and augite, with a number of accessory minerals, the most common being olivine and magnetite. These rocks are of dark-gray or black color, usually fine-grained and quite difficult to break with a hammer. As a road-surfacing material, this class of rocks has no equal. Its great hardness and

its remarkable toughness, together with its excellent binding quality, make it an ideal road-building material.

There are a number of localities along the several railroads of North Georgia, where quarries of this superior road-material can be opened up at a small cost, and the stone can be readily shipped to all parts of the State, for both street and road purposes. The trap rock of the State is almost unknown; and, as a consequence, it has had no use in road-construction.

Hornblende-Schist.—Associated with the diorites, and frequently indistinguishable from them, except by microscopic examination, are the hornblende-schists. These rocks differ from the diorites mineralogically in that they have quartz as a constituent, instead of feldspar. They are very abundant and quite generally distributed throughout the Crystalline area. The hornblende-schists, like the diorites, occur in the form of bands or belts in the mica-schists. These belts are usually narrow; but occasionally they expand to the width of several hundred feet. The rock is always laminated and fine-grained. The less distinctly laminated varieties make a fair road-building material. These varieties are quite tough, and give excellent service, when used for road-surfacing.

Mica-Schist.—The mica-schists, which are the most abundant of all the Crystalline rocks, are widely distributed. They consist of mica and quartz, and are always distinctly laminated, which renders them practically unfit for road-material.

Quartzite.—The quartzites or sandstones of the Crystalline area are limited to a few localities. The most extensive exposures of this class of rocks form a chain of low ridges and hills, extending from near Barnesville, Georgia, to the Alabama State-line by the way of Warm Springs, Chipley and Hamilton. These sandstones are usually thin-bedded and occasionally flexible. In places, they become quite compact, and pass into hard quartzites. These rocks have been used to a limited extent in the vicinity of Pine mountain for road-material; but they are usually too friable, to withstand the wear of traffic, and hardly deserve to be classed among the road-building materials. Similar sandstones or quartz-

ites occur along the line separating the Paleozoic from the Crystalline area, and also on Graves mountain, an isolated monadnock located in the western part of Lincoln county.

Marble.—Marble or crystalline limestone occurs in Cherokee, Pickens, Gilmer and Fannin counties, forming a narrow belt along the Atlanta, Knoxville and Northern R. R. The stone has been used to a small extent in the vicinity of Tate for road purposes; but owing to its coarse grain it is not well adapted for that use.

Gravel.—Quartz pebbles and bowlders, which have resulted from the breaking down of quartz veins, are very common throughout the Crystalline area. They are so abundant, in many places, as to interfere with the cultivation of the soil. Large quantities of them have been used on the railroads for ballast, and, in a few places, they have had a local use for road-macadam. They are poorly suited for the latter purpose, on account of their brittleness and their lack of binding quality.

THE ROAD-BUILDING MATERIALS OF THE TERTIARY AREA

The Road-building materials of the Tertiary area are limestone, buhrstone or flint, and gravel. In the vicinity of the coast, shells also have had a limited use in road-surfacing.

Limestone.—The limestones of South Georgia outcrop at many points throughout the Coastal Plain. They are exposed most abundantly along the streams, in the vicinity of lime-sinks or lakes. They are also occasionally seen in the cuts of the various railroads traversing that part of the State. These limestones are usually soft and of a porous nature; though, occasionally, they become quite compact and are partly crystalline. The softer varieties, in places, consist mainly of fragments of shells and a limited amount of sand cemented together by a calcareous matrix. This class of limestone has been used, to a considerable extent, for road- and street-surfacing, both in South Georgia and Florida; and it seems to give entire satisfaction. It readily cements into a compact hardened surface, comparatively free from dust. This mate-

rial has been used in the last few years on some of the streets in the city of Macon, where it has given good results. The cheapness, with which these soft limestones can be prepared and put in place on the roadbeds, makes them the most valuable material of the Tertiary area for road-surfacing. The hard limestones of South Georgia appear to have but little use, so far, in road-construction. Nevertheless, they are more or less widely distributed; and they seem to be fairly well adapted to that purpose.

Buhrstone or Flint.—Buhrstone or Flint is quite abundant along the Georgia-Florida State-line, and also at many points further north. It is usually of a porous nature, and has evidently originated from the silicification of the limestone, with which it is frequently associated. These siliceous deposits sometimes occur, in more or less continuous layers, often three feet or more in thickness; but, as a general thing, they appear as boulders or detached masses imbedded in the sands or clays. The buhrstone is quite brittle; and it could hardly be used alone to advantage for road-surfacing; but, if mixed with the soft limestones, which often are found near by, it would probably make a fair road-surface.

Gravel.—Gravel deposits are quite plentiful along the northern border of the Tertiary area, where they are often seen, in thick beds outcropping beneath the superficial layers of sand. The pebbles are all water-worn, and evidently mark the limit of an old shore-line. They are often cemented by ferruginous, sandy clays, and make excellent material for road-surfacing. Many exposures of these gravel deposits are to be seen in the vicinity of Augusta, Milledgeville, Macon and Columbus. They are also frequently found in small, local beds, as far south as Bainbridge. These gravel deposits are well exposed, just across the Savannah river from Augusta, near the Port Royal and Augusta Railroad. At this point, the gravel has been extensively worked for the last few years, and shipped to Augusta and Savannah, where it is used for both street- and road-surfacing. The binding material of this gravel is a ferruginous, sandy clay, which readily hardens into a compact mass on being dampened and rolled, forming an excellent road-surface, which is both durable and free from dust.

CHAPTER IX

THE ROADS OF GEORGIA, WITH A BRIEF DESCRIPTION OF THE EQUIPMENT, METHODS OF ROAD-WORKING, AND MATERIALS, BY COUNTIES

DADE COUNTY

Area, 186 square miles; approximate road-mileage, 140; number of miles of graded road, 0; number of miles of gravel road, several; amount of money raised annually for public-road purposes, \$1,100; number of days worked by road hands each year, 4. The roads are constructed and maintained by statute and free hired labor.

Dade county lies in the extreme northwestern corner of the State. Its eastern portion is traversed by Lookout mountain; while much of its western portion, on Sand mountain, is a comparatively level plateau. The topographical features of Dade county offer no serious difficulties in the way of road-construction, except where the roads ascend the mountain. The roads at present are kept up by statute labor, supplemented by free hired labor. Each militia district has one overseer, who is paid \$1.00 per day, while actually engaged on road-duty. Hired free labor, when employed, is paid 75 cents per day. The county has no road-machinery or tools, except scrapers, picks and shovels. The road-building materials are mainly limestone and chert. Sandstone is also abundant in the western part of the county; but it is usually so friable as to render it almost worthless for constructing a hardened way. The chert belongs to the Fort Payne formation, and is well suited for road-surfacing. Dade county levies a special road-tax, of one mill on the dollar, which, last year, amounted to \$1,100.

WALKER COUNTY

Area, 404 square miles; total road-mileage, 750; number of miles of graded road, 20; amount of money annually raised for public-road purposes, \$2,619. The roads are constructed and maintained by statute and hired labor.

The topography of Walker county is varied. The extreme eastern and western parts of the county are distinctly mountainous; while the surface of its central portion consists of parallel valleys separated by low, broad, well-rounded ridges. The roads in the mountainous section usually have steep grades; though, on account of the sandy nature of the soil, they are easily drained, and therefore rarely ever become so extremely muddy as the roads in the valleys. Some of the valley roads, where they are underlain by the Chickamauga limestone are quite rocky. A good example of a road of this character is the highway extending from Estelle, at the foot of Pigeon mountain, to Chattanooga. Such roads as this, however, could be easily repaired and put in first-class condition at a comparatively small cost, owing to the abundance of excellent road material at hand.

The twenty miles of graded roadway, referred to above, is the U. S. national road, extending from LaFayette to Rossville. This road, which is an ideal chert roadway, is an excellent object-lesson to the citizens of that section of the country; and there can be but little doubt, that it will do much toward the betterment of the roadways in the county. In addition to the grading of the national road, there has also been a limited amount of grading done in the vicinity of LaFayette, and at several points on the road crossing Taylor's ridge. Most of the money collected for road purposes is spent either in this way, or in graveling the worst places along the main highways. It is estimated, that there has been about 20 miles of road graveled, in the last few years at an average cost of \$100 per mile. This cost of graveling seems to be unusually small. However, it must be borne in mind, that the gravel can often be obtained directly from the roadside, so that the expense of hauling is reduced to a minimum.



PHOTO-MICROGRAPH OF GRANITE, FROM THE HAMES QUARRY,
KENNESAW MOUNTAIN, GEORGIA.
BETWEEN CROSSED NICOLS X 75.

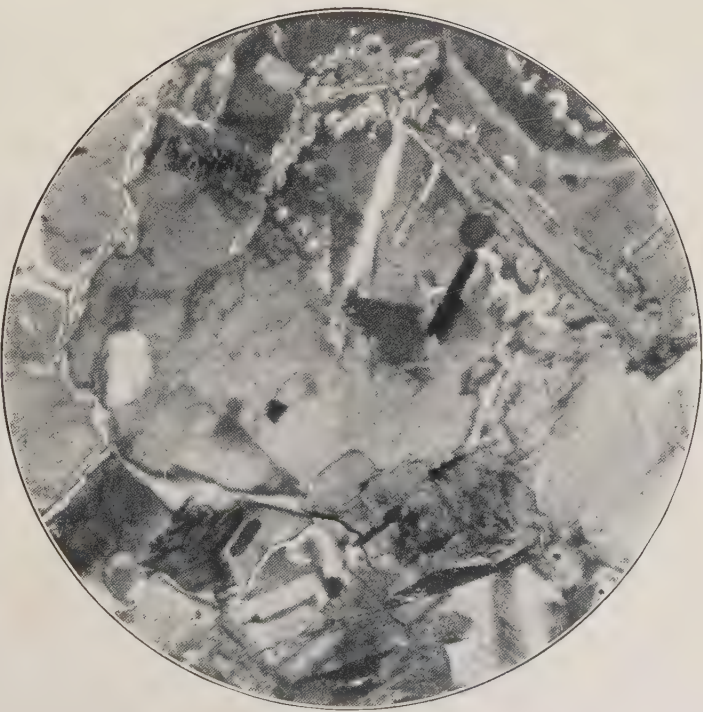


PHOTO-MICROGRAPH OF STONE MOUNTAIN GRANITE, FROM
STONE MOUNTAIN, DEKALB COUNTY, GEORGIA.
BETWEEN CROSSED NICOLS X 75.

The roads of Walker county are worked, under the road law of 1897. Each person subject to road-duty is required to work on the public roads four days each year, or pay a commutation-tax of \$3.00. About \$300 is reported to be received by the County Ordinary annually, as commutation-taxes. The remaining part of the money received for road purposes is obtained by an assessment, of one mill on the dollar for all real property. In the last few years, Walker county has constructed four steel bridges at a total cost of about \$2,500.

The road-building materials of the county are abundant and widely distributed. They consist of chert and limestone. Both the Fort Payne chert and the Knox Dolomite chert abound. The former is confined chiefly to the base of Lookout and Pigeon mountains; while the latter occurs in the Dolomite ridges traversing the central part of the county. The limestones are found throughout all the valleys. The Chickamauga limestone is especially abundant and is well suited for road material.

CATOOSA COUNTY

Area, 149 square miles; total road-mileage, 200 miles; number of miles of graded road, 40; number of miles of macadamized road, 40; amount of money annually raised for road purposes, \$850. The roads are constructed and maintained mainly by statute labor.

For the last two years, Catoosa county has levied a special road-tax of one mill on the dollar, and a commutation-tax of three dollars on each individual subject to road-duty; or, in lieu thereof, four days' labor per year. From these two sources, there is collected usually about \$850, which is distributed to the several districts of the county to be used in the improvement of the highways. The ordinary says, that the system is satisfactory, and the roads are being improved.

The graded and macadamized roads of Catoosa county have all been constructed by the United States Government within or near Chickamauga Park. These are excellent roadways with

easy grades. The hardened surface consists of two layers of stone. The lower layer is made of limestone and the upper, of chert. The former makes a superior foundation; while the latter gives a smooth, uniform wearing-surface, comparatively free from dust. These National roads are all models of highway improvement; and they will no doubt exert a strong influence in that part of the State, toward the betterment of the public roads.

The road-surfacing materials of Catoosa county are everywhere abundant. They consist of the Knox dolomites, Chickamauga limestones and cherts. The last two varieties of road-building materials occur in the same formation, known as the Knox Dolomite series. This formation gives rise to broad ridges, traversing the county in a northeast-and-southwest direction. Near the base of these ridges, often occur heavy deposits of chert, quite free from clay and other objectionable materials. Such material requires little or no preparation for road-surfacing; and, as a consequence, gravel roads in this county can be constructed at minimum cost. There is probably no portion of the State so abundantly supplied with cheap road-material as Catoosa county.

WHITFIELD COUNTY

Area, 285 square miles; approximate road-mileage, 500; number of miles of graded road, several; number of miles of macadamized road, a few; amount of money annually raised for public-road purposes, \$1,800. The roads are constructed and maintained by statute and free hired labor.

The eastern part of Whitfield county is broken, and the surface is irregular; while the central and western parts consist of a number of parallel ridges and valleys. Some of these ridges, as in the case of Chattoogata mountain and Taylor's ridge, often attain an elevation of several hundred feet above the intervening valleys and become serious obstacles in the way of road-building. The soils of the county, especially those formed from the weathering of the Oostanaula shales, are very unfavorable for road-construction.

tion. When wet, they are easily worked into a tough, tenacious mud, which often renders the roads, in places, almost impassable.

The Ordinary, in speaking of the highways, says: "We are working, under what is known as the conditional road law of 1890 and 1891. Our roads are being gradually improved; and we only need more money, and it well applied, to soon have good roads."

The county levies a special road-tax of nine-tenths of a mill on the dollar, of all taxable property. The money thus collected is proportioned out to the various districts, where it is expended in hiring hands to work on the roads.

The county owns two iron bridges, and a half-interest in five others, which have been recently constructed at a cost of about \$2,000 each.

The road materials are abundant. They consist mainly of limestone and shales.

MURRAY COUNTY

Area, 410 square miles; approximate road-mileage, 212; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, 0; average number of days worked by hands each year, 6. The roads are constructed and maintained by statute labor.

Murray county lies in the northwestern part of the State, chiefly within the Paleozoic area. Its surface in the eastern part is quite mountainous; while the western portion is undulating. Many of the higher mountains in the eastern part of the county, such as Cohutta and Bald, have an elevation of more than 3,000 feet above the sea-level. Passable roads for wagons in the mountain sections are found along the streams. Such roads always have steep grades, and are often difficult to maintain. The roads of the eastern part of the county have much better grades, and they are generally kept in fair condition for traffic. The materials for road-surfacing are quite abundant. They consist mainly of limestone, dolomite and chert. The limestone occurs mostly as thin beds in the Connasauga shales, which are widely distributed

over the county. Chickamauga limestone also occurs; but it, like the Knox dolomite and chert, is confined to the northern part of the county. In the mountainous portion of the county, the geological formations consist largely of conglomerates and metamorphic sandstones with slates. Murray county, aided by Whitfield county, has constructed in the last few years seven bridges across the Connasauga river at a cost of about \$2,500 each.

GORDON COUNTY

Area, 351 square miles; total road-mileage, 350; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

The Chairman of the Board of the County Commissioners, in speaking of the condition of the highways in Gordon county, says: "Our present way of working our public roads is very unsatisfactory. We have very poor roads in Gordon county, and will continue to have, so long as our present system prevails. There is some talk of making a change in our present method of working the roads."

The road materials of Gordon county consist of limestones and cherts. The former belong mostly to the Knox Dolomite formation; although there are, in places, considerable outcroppings of limestone, suitable for road-surfacing, occurring in the Connasauga shales. Both these calcareous formations are compact, and well adapted for road-metal. They are quite generally distributed throughout the county.

The chert of Gordon county occurs in both the Knox Dolomite and the Fort Payne formations. A good exposure of the former occurs in the vicinity of Sugar Valley, elsewhere described; while the latter may be seen along the ridges immediately west of Calhoun. Chert from both these localities has been used, to a limited extent, in road-surfacing, and has given general satisfaction.

CHATTOOGA COUNTY

Area, 331 square miles; approximate road-mileage, 450 miles; number of miles of graded road, several; number of miles of chert road, 30; amount of money annually raised for public-road purposes, \$2,200. The roads are constructed and maintained by statute and free labor.

The highways of Chattooga county are under the direct management of district superintendents, appointed by the Board of Commissioners. These superintendents proportion the hands to the several roads of their respective districts; appoint overseers; direct the expenditure of all money collected for road purposes; and make regular reports or statements to the Board of Commissioners. For these duties, the superintendents are paid 60 cents per mile for each mile of road in their respective districts. The overseers are allowed \$1.00 for each time the hands are subpoenaed to work the roads. These expenses, together with team-hire for road-working, building and repairing bridges, etc., are all paid for, by the special tax of one mill on the dollar, which is raised for general road purposes. All persons residing in the county and subject to road-duty are required to work six days annually upon the highways, or pay a commutation-tax of \$3.00. The alternative is rarely ever taken advantage of, on account of the high-rated money-value placed upon a day's labor.

The Chairman of the Board of Commissioners is favorably impressed with their present method of keeping up the public roads. He says, it is quite an improvement over the old system. However, there is still a lack of money, and too much unconformity in the method, to yield satisfactory results.

The surface of Chattooga county is hilly and uneven. It is traversed, in a northeast-and-southwest direction, by numerous ridges, which makes road-building, at right-angles to their direction, both difficult and expensive. The main roadways are usually located in the valleys, and are connected with each other by cross-country roads, constructed through low gaps or depressions in the ridges.

The materials suitable for road-surfacing are very abundant in Chattooga county. They consist of the Knox dolomite, Chickamauga and Mountain limestones, and chert. Both the Fort Payne and the Knox Dolomite cherts are found here in large quantities. The latter deposits have been extensively worked in the last few years on the Chattanooga, Rome & Southern R. R., about a mile south of Summerville. From this point, the chert has been shipped to Savannah, Macon and other places, for street-surfacing. The chert occurs here in a cut along the railroad, where it can be loaded on the cars at a small expense. It is comparatively pure. Nevertheless, there is, in places, considerable clay, which should be removed, if the best quality of roadbed is desired.

FLOYD COUNTY

Area, 539 square miles; approximate road-mileage, 500; number of miles of graded road, 100; number of miles of macadamized road, 100; amount of money annually raised for public-road purposes, from \$10,000 to \$12,000. The roads are constructed and maintained by convict labor.

No county in the State has done more toward the improvement of its highways than Floyd. Mr. Halsted Smith, of Rome, the county-seat, in an address before the National Road Conference at Asbury Park, N. J., gives the following information, concerning road-maintenance in Floyd county:¹ "In Floyd county, in which I live, the convict system has been tried. The object of the Board of Commissioners of Roads and Revenues, which inaugurated the system, was to take Rome, the county-seat, as a central point, and to have roads radiate from that, as from a hub, making the main thoroughfares as the spokes of a wheel. This system of convict work was inaugurated, in November of 1881; there was a report made, in the latter part of last year, by the Secretary of the Board of Commissioners of Roads and Revenues showing the cost to the county of this system. Beginning in November, 1881, the work

¹ Proceedings of the National Road Conference, Held at the Westminster Church, Asbury Park, N. J., July 5th and 6th, 1894, p. 40.

for twelve years had cost \$116,000. In expending that, they had worked upon these nine main thoroughfares leading from the county-seat, and a total amount of 70 miles had been graded and macadamized. That would make the cost \$1,657 per mile. However, from that, there must be deducted the cost of bridges; the approaches; and the expense of building piers and abutments, which made, of course, a greater sum total.

"The superintendent of the chain-gang claims, that he works, and puts in order the ordinary country-road, of 16 feet in width, at a cost of \$1,200 per mile; and from figures, that I have made myself with reference to it, I believe, that he is nearly correct upon that subject.

"As I said, there are nine main thoroughfares. In addition to those outside of the corporate limits of Rome, the chain-gang has worked about two miles inside of the city limits. The roads inside the city limits were 30 feet wide; for two miles from the corporate limits out, the roads were made 20 feet wide for a certain distance; and beyond that, they were made 16 feet wide. We have a sandy soil there; and the road is first graded by means of road-plows; and then it is macadamized inside the city to the depth, for a distance of two miles out, of 15 inches in the center, going down to nine inches on the side of the macadam; farther out than that, the depth of the macadam is only nine inches in the center, and six inches on the side. The stone for this macadam has been obtained in two different ways. We have mostly limestone in that country; some of it has been blasted out, and crushed with a stone-crusher, and then put upon the road; and another portion of the macadam has been obtained from the loose stones and gravel upon our mountain-side. The crushed stone makes much the better road, much smoother and firmer, for the reason that, being comparatively soft, it makes a cement of itself.

"The average number of convicts, who have been worked during that time, was, for the first seven years, 35, and for the last five years, 45; and, as I said before, the total cost has been \$116,000 for twelve years.

"It may be interesting to you, if I state the increase in the taxable value of property in the county of Floyd. That is not a wealthy county ; yet, in 1881, the taxable property was four and three-fourths millions, and, in 1893, it was \$9,043,389. You will therefore see, that along with this road improvement, there has been an increase of nearly 100 per cent. of taxable value, besides the addition of ease and comfort to those, who travel over the road. In Floyd county, the custom has been, during the spring, summer and fall months, to work the convicts along the highways, where they could be in the neighborhood of the camp. In the winter months, when the weather is somewhat more severe, they are put in permanent houses near the corporate limits, and work in and about the city ; so that they do not have to go very far from their place of sleeping to their place of work."

Since the address of Mr. Smith before the road conference at Asbury Park, there has been practically no material change in the method of road-working in Floyd county. Besides the chain-gang, statute labor is also employed in the county. All the main roadways in the distant part of the county, and some of the less important ones in the vicinity of Rome, are kept up entirely by statute labor.

During the summer of 1897, the writer in company with Mr. Norris Smith, formerly of the U. S. Geological Survey, examined a number of the leading highways radiating from the city of Rome, which had been constructed by the county chain-gang. These hardened ways, as a general rule, were found to be in excellent condition ; but, in places, the grades were rather steep and the alignment was bad. Some of these roads, in places, should have been re-located before any grading or macadamizing was attempted. This would have added not only to the beauty of the roadways ; but, at the same time, it would have reduced the cost of construction. The materials used in surfacing these roads are limestones, shales, chert and gravel, all of which have wide distribution in Floyd county.

Of these several materials, probably the limestones are the most

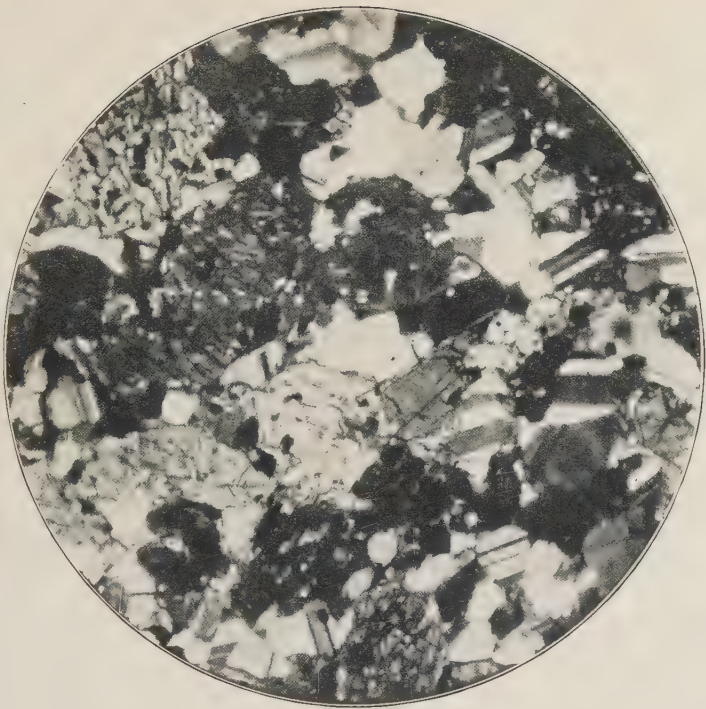


PHOTO-MICROGRAPH OF DIABASE FROM A CUT ON THE SOUTHERN RAILWAY, NEAR SOUTH RIVER, DEKALB COUNTY, GEORGIA. BETWEEN CROSSED NICOLS x 75.

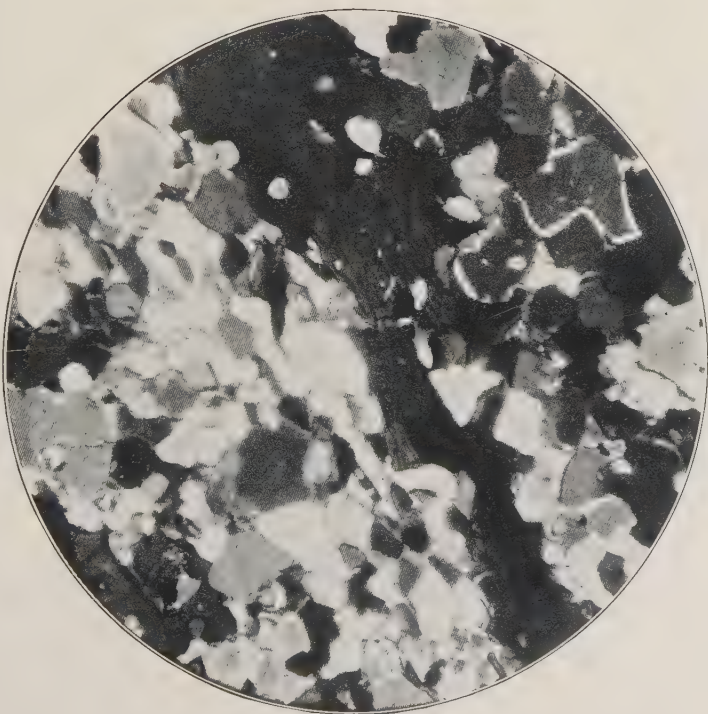


PHOTO-MICROGRAPH OF QUARTZ-DIORITE, FROM LAKEWOOD, FULTON COUNTY, GEORGIA. BETWEEN CROSSED NICOLS x 75.

durable and suitable for general road-construction ; but, at the same time, it is more expensive than either of the other materials, on account of the cost of preparation. The gravel and the chert, and also the shale, are generally put down with little or no preparation ; but the limestone has to be crushed. The economic use of these several materials depends, in a great measure, upon their proximity to the road to be surfaced. For instance, it would not be economy to haul limestone a mile or so, if shale or gravel could be had at a less distance.

In addition to the improvement of the roadways, Floyd county, in the last few years, has constructed ten iron bridges at a total cost of \$75,000. The money expended for road-purposes is raised by an assessment of an eighth of a mill on all taxable property. No commutation-tax is assessed.

The road-working outfit cost several thousand dollars. It consists of one complete portable rock-crushing plant, one road-machine, scrapers, plows, quarrying tools, blacksmith's tools, a camping outfit, 22 mules, wagons etc.

The chain-gang is under the direction of a superintendent, who receives a salary of \$50.00 per month. There are also regularly employed three guards, each paid \$30 per month. The number of convicts now employed in the county chain-gang varies from 40 to 75. Some of the convicts are hired from other counties, the prices paid being from \$2.00 to \$4.00 each, per month.

BARTOW COUNTY

Area, 491 square miles ; approximate road-mileage, 500 ; number of miles of graded road, 20 ; number of miles of macadamized road, 5 ; amount of money annually raised for public-road purposes, not ascertained. The roads are constructed and maintained by statute labor.

The highways of Bartow county were kept up, in a great measure, by convict labor, for a number of years previous to 1898. During the time this system of road-working was in operation,

from fifteen to thirty convicts were regularly employed ; and from \$6,000 to \$7,000 was annually raised for public-road purposes. But, on account of mismanagement, or for some other reason, the system was abandoned, as expensive ; and statute labor was again instituted. Many of the leading thoroughfares, radiating from Cartersville, the county-seat, were kept in good condition by the convicts during the time the new road law was in operation ; but, since the abandonment of the system, these roads are said to be poorly maintained. The writer has been informed, that there is now a growing sentiment in the county in favor of re-establishing the chain-gang system of road-improvement.

Bartow county has constructed in the last few years two excellent bridges at a cost of \$15,000.

The road-materials are abundant. They consist of limestones, schists, chert and gravel. The limestone and chert are the most widely distributed, and are the best suited for road-surfacing.

Topographically, Bartow county may be considered hilly ; although there are no very marked obstacles in the way of road-building. The hills and ridges are generally well rounded, and the valleys are broad. The streams are numerous ; but they are mostly small, and are not expensive to bridge. The soils are chiefly red clays, which make good roadways, as long as they are properly drained and kept dry.

POLK COUNTY

Area, 330 square miles ; approximate road-mileage, 200 ; number of miles of graded road, 0 ; number of miles of macadamized road, 0 ; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

Polk county lies mainly within the Paleozoic area ; and, as a consequence, it has abundance of limestone and chert suitable for road-surfacing. Topographically, the northwestern portion of the county is somewhat rugged, due to the presence of chert hills and

ridges. The northern portion is more or less level, with low, well rounded hills and ridges. The same may be said of the southern portion of the county, with the exception of the region in the vicinity of Lime Branch Post-office, where the cherty ridges become quite prominent and the surface is much broken. The topographic features of the county as a whole present no very serious problems in the way of road-building.

Dr. J. W. Spencer, formerly State Geologist of Georgia, in speaking of the roads of Polk county, says :¹ "Throughout Polk county, the valley roads have often good grades ; but, over the ridges, they are often steep. The roads over the slaty formation are usually good. Those over the decayed limestone formations are liable to be cut into deep ruts during the wet seasons. The roads over the chert formations are more certain. Owing to the various distribution of chert and limestone, valuable material for road-making would be available in many places." Besides the limestones and cherts, above mentioned, there are also at many places local beds of impure iron ore and gravel deposits, well suited for road-surfacing. The highways of Polk county are in fair condition. They are kept up at present entirely by statute labor. The number of days annually worked on the road by persons subject to road-duty is reported to be about ten. This is more than the average for the State ; and it accounts for the good condition of the roads.

The county in the last two years has constructed two iron bridges, valued at \$3,000.

HARALSON COUNTY

Area, 269 square miles ; total road-mileage, 200 ; number of miles of graded road, 0 ; number of miles of macadamized road, 0 ; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

Topographically, Haralson county is generally hilly, and the roads, in places, have steep grades. Gneisses and schists are the

¹ Geological Survey of Georgia ; First Report of Progress, 1890-'91, p. 128.

prevailing rocks of the county. Massive quartz, resulting from the breaking down of quartz veins, and diorite also occur. The latter is a dark, speckled rock, usually very tough, and well suited for road-metal.

But little interest seems to have been manifested in the county, so far, in the betterment of the highways. The county has in the last few years constructed four iron bridges at a total cost of \$12,000; but, otherwise, there has been little or no money expended upon the roadways. The roads are kept up solely by statute labor. Each person, subject to road-duty, is said to work on the public roads, on an average of six days per annum.

PAULDING COUNTY

Area, 340 square miles; approximate road-mileage, 250; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

Paulding county is hilly; and the roads often have steep grades. Many of the leading thoroughfares are poorly located, and need to be re-surveyed before any permanent improvement is attempted. Road materials of fair quality are plentiful. They consist of granite, gneiss, schist and diorite. The gneisses and schists are especially abundant and widely distributed; while the granite and diorite occur in large exposures; yet, they are more local in their distribution. The following is a description of a typical specimen of Paulding county diorite, taken from a cut on the Southern Railway, one mile west of Dallas. The exposure, from which the specimen was obtained, extends for some distance along the railroad, and is evidently the denuded outcropping of a huge dike, having a total thickness of several hundred feet. The rock occurs in layers, some of which seem to be quite massive; while others are distinctly schistose. The prevailing color is black-and-white-speckled, though some of the layers are almost black, due to the

superabundance of hornblende present. The texture is usually fine; yet all the essential mineral constituents can be made out, without the use of the lens.

Microscopically, the rock is seen to consist of hornblende, plagioclase, quartz, epidote and pyrite. The hornblende, which is the most abundant mineral, has a pale-green color, and appears in the form of irregular crystals and plates with numerous inclusions of epidote.

Many of the crystals of hornblende show prismatic cleavage. The plagioclase is poorly striated and polarizes in low colors. It occurs in irregular grains, which, like the quartz, frequently exhibit irregular extinction. The rock has a schistose structure; but otherwise it has all the characteristics of a first-class road-surfacing material.

Hornblende-schist is of common occurrence in Paulding county. Several exposures of this rock are seen in the railroad cuts between Dallas and Hiram. It is often too distinctly laminated for good road-material. Both the diorite and the hornblende-schist occur in narrow belts or zones, which sometimes continue for long distances without interruption. They always conform in strike and dip with the associated rocks.

CHEROKEE COUNTY

Area, 409 square miles; approximate road-mileage, 500; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, from \$1,500 to \$3,000; number of days worked on roads each year, 5. The roads are constructed and maintained by statute labor.

Cherokee county is generally rolling, and the highways in places often have steep grades. The materials for road construction are quite abundant, and well distributed throughout the county. They consist of gneisses, hornblende schists and crystalline limestone. The two first named varieties of rock are very

abundant, being found more or less plentiful in every district. They are generally fine grained and well suited for macadam. The hornblende rocks are especially abundant in the southern portion of the county, where they give rise to the red hills of that section. The crystalline limestone or marble is quite local in its distribution. It occurs chiefly in the vicinity of Mable Station and Ball Ground, in beds of considerable thickness. The limited distribution of this rock prohibits it from ever becoming of general use for road-construction. Besides the above named rocks, large quantities of massive quartz in the form of angular fragments are also of common occurrence. These quartz rocks, which have originated from the breaking down of the quartz veins in the schists and gneisses, are often used for road-surfacing, when no other better material is at hand.

Cherokee county has, in the last few years, constructed five iron bridges at a total cost of*about \$18,000.

PICKENS COUNTY

Area, 276 square miles; approximate road-mileage, 500; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, 0; number of days worked by road hands each year, 3. The roads are constructed and maintained by statute labor.

Topographically, the greater portion of Pickens county is mountainous. This is especially true of that part of the county lying east of Long Swamp creek, where Glassy and other mountains attain an elevation of more than 3,000 feet above the sea-level. The roadways are often steep; but otherwise they are kept in fair condition for traffic.

The road materials are granites, gneisses, schists, hornblende rock and marble. The last named road-building material is found in great quantities in the eastern part of the county, along Long Swamp creek, where it is now being quarried in great abundance, for building and ornamental stone. These marbles are usually

coarse-grained, and, as a consequence, rather poorly suited for road-surfacing. However, the large amount of waste about the quarries in the form of spalls, fissured blocks etc., makes this material of local interest in road-construction. Associated with the marble and often penetrating it, as intrusive masses, occurs the hornblende rock, *amphibolite*. This rock, which is abundant in the vicinity of Marble Hill, is a very tough, dark-colored rock, made up of dark-green hornblende and quartz. It is an excellent road material. Similar rocks are reported as occurring in other portions of the county; but their extent and character have not been investigated. The most common and widely distributed rock in Pickens county, suitable for road-building material is the gneiss.

The Ordinary of the county, in speaking of its highways, says: "Our roads are worked in the old way by statute labor, under commissioners and overseers. The system seems to be satisfactory to the people."

GILMER COUNTY

Area, 452 square miles; total road-mileage, 200; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

The surface of Gilmer county is generally hilly, and the roads in places often have steep grades. The road materials are plentiful, and quite generally distributed throughout the county. They consist of gneisses and schists, with an abundance of massive quartz. Extensive beds of slate and conglomerate also occur; but neither is well suited for road-surfacing.

The highways of Gilmer county are maintained solely by statute labor. Each individual, subject to road-duty, is said to work on the highways, on an average, about six days each year. The roadways are reported to be in fair condition throughout the county; and the system, under which they are maintained, seems to be satisfactory to the majority of the people.

FANNIN COUNTY

Area, 409 square miles ; approximate road-mileage, 200 ; number of miles of graded road, 0 ; number of miles of macadamized road, 0 ; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

Fannin county is situated in the extreme northern part of the State. Its surface is quite mountainous. Many of the higher ridges and peaks attain an altitude of more than 4,000 feet above sea-level. The construction of first-class roads with easy grades in Fannin county is both difficult and expensive. During the early history of the State, applications were frequently made to the Legislature for aid in building passable roads throughout these mountainous districts. The chief roadways of the county are usually located along the streams. The ridges are generally crossed at the lowest gaps ; but, even then, the ascents and descents are frequently quite precipitous. The streams are usually rapid and rarely bridged. When swollen by heavy rains, they become torrents, dangerous to cross and destructive to bridges, unless they are securely constructed. The writer, during a visit to this county, some three years ago, found many of the leading highways in good condition, considering the ruggedness of the country, and the system under which they are maintained. The roads of the county are worked, on an average, only about five days each year. The present system of road-working seems to be generally satisfactory to the public ; consequently, there is not likely to be any change soon in the method of highway-improvement. Fannin county has an abundance of gneiss, schists, massive quartz etc., suitable for road-surfacing.

UNION COUNTY

Area, 325 square miles ; approximate road-mileage, 150 ; number of miles of graded road, 0 ; number of miles of macadamized road, 0 ; amount of money raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

THE ROADS AND ROAD-BUILDING MATERIALS OF GEORGIA

PLATE XV



PHOTO-MICROGRAPH OF OLIVINE-DIABASE FROM THE WEEK PLANTATION, 4 MILES SOUTH OF FORSYTH, GEORGIA.
BETWEEN CROSSED NICOLS X 75.

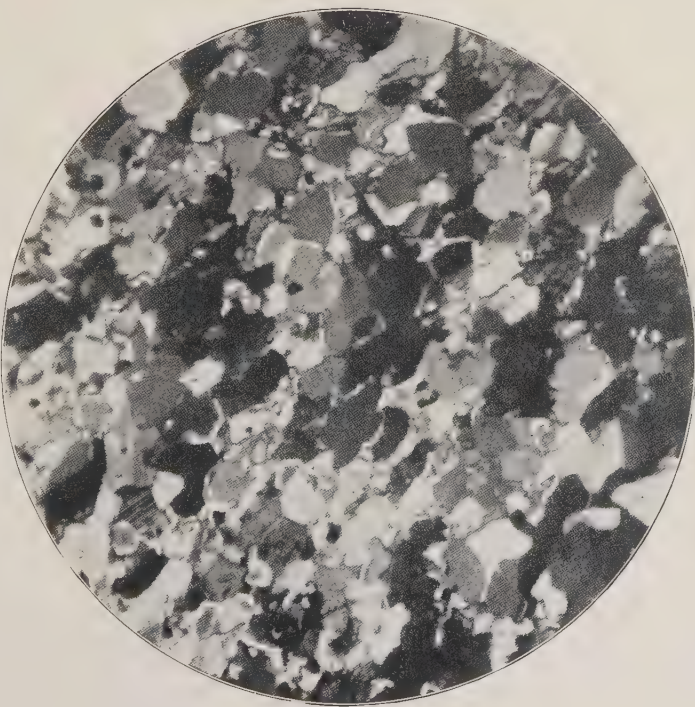


PHOTO-MICROGRAPH OF QUARTZ-DIORITE FROM THE ROADSIDE, 2 MILES WEST OF JACKSON, BUTTS COUNTY, GEORGIA.
BETWEEN CROSSED NICOLS X 75.

There is probably no county in the State, which presents more obstacles in the way of highway-construction, than Union. This is due largely to the unusually rough and mountainous condition of the surface. The great cost of building good roads throughout the country has, in a measure, retarded the development of its natural resources. The county is naturally rich in minerals, timbers, water-powers etc.; but they are rendered valueless, to a great extent, by reason of the poor condition of the highways. The value of good roads has been fully realized by all the leading citizens of the county, for many years. This is shown by the organization of the following companies: The Union Turnpike Company, incorporated in 1834, to extend a turnpike from Loudsville, White (then Habersham) county, through the Tesnatee Gap by way of Blairsville to some point on the northern boundary of the State. The Union, Lumpkin and Habersham Company, incorporated in 1841 for the purpose of constructing a road from Maj. Francis Logan's in Habersham county by way of Tesnatee Gap to James Hall's in Union county. The capital stock was \$8,000, divided into shares of \$25 each. The Union and Lumpkin County Turnpike Company, organized in 1843, to build a road from Jonathan Oxford's, Lumpkin county, *via* Tesnatee Gap to James Hall's in Union county.

The object in organizing these companies was to construct toll-roads through the sparsely settled mountainous districts, where statute labor was insufficient to keep the roads in a passable condition.

The county Ordinary, in speaking of the condition of the roads in Union county, says: "We keep up our roads by statute labor. The method is very unsatisfactory. Our roads are bad. They should be worked by taxation, the only system, by which public-roads can be kept in a good condition."

The roads are worked, on an average, about five days each year. Many of them, especially those crossing the higher ridges, have steep grades; and in the winter they become almost impassable for heavy traffic. The streams are rapid; and, when swollen by heavy

rains, they become impassable. There are but few bridges in the county, and these are not always kept in good condition.

The road materials are granites, gneisses, mica- and hornblende-schists and massive quartz, the last resulting from the breaking down of quartz veins. The gneisses are widely distributed. They are probably the most valuable rock to be found in the county, for general road-purposes.

TOWNS COUNTY

Area, 180 square miles; approximate road-mileage, 100; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, 0; number of days worked on the public-roads each year, 5. The roads are constructed and maintained by statute labor.

Towns county is quite mountainous, and the construction of roads with easy grades is quite costly. The majority of the roadways are poorly laid out, and should be re-located before any grading or any other work of a permanent nature is undertaken.

The road materials are granites, gneisses, schists and trap. Gravel also occurs in considerable abundance in the streams.

As a general rule, the roads of the county are steep, and are rarely kept in good condition. It would require an enormous amount of money to construct first-class roads with easy grades throughout Towns county, on account of the mountainous and rough condition of the surface.

RABUN COUNTY

Area, 464 square miles; approximate road-mileage, 300; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, 0. The roads are maintained and kept up by statute labor.

Rabun county lies in the extreme northeastern corner of the State. Its topographic features are distinctly mountainous. The streams are numerous and rapid, and when swollen by rain

or melting snow, are very dangerous to ford. The main thoroughfares of the county generally follow the streams in the narrow valleys. In places, the grade of the roads are unusually steep, as may be seen in the road leading from Clayton to Laurel Creek. Such roads should be re-located before any expensive repairs are attempted. The road leading from Clayton to Clarkesville, was formerly a toll-road, and is now a fair county-road, though in places it has steep grades. Materials for road-building in Rabun county are abundant and widely distributed. They consist of granite, gneiss, hornblende-schist and trap rock. The gneisses are the most common, available for road-purposes. They are found in all parts of the county, and are generally compact and fine-grained. Hornblende-schists are also abundant. Dr. Francis P. King, formerly Assistant Geologist on this Survey, speaks of this rock's being found more or less plentiful, in the northeastern part of the county, in the vicinity of Laurel Creek. Trap rock has been seen by the writer at only one place in the county. This exposure is at the Smith Gold mine near Burton, in the western part of the county. The trap here occurs in the form of a small dike, only a few feet in thickness. A large deposit of this same stone is reported to occur on the road to Tennessee valley, about $2\frac{1}{2}$ miles north of Clayton.

Rabun county, in the last few years, has constructed three iron bridges at a cost of \$6,000. The roads are worked, on an average, about six days each year. They are said to have been much improved in the last few years.

HABERSHAM COUNTY

Area, 347 square miles; total road-mileage, 300; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

Habersham county is generally mountainous, and the cost of constructing roads with easy grades throughout its several districts,

would involve the county in an enormous debt. The question of constructing passable roads through the more mountainous portions of Habersham has been agitated for years. In the early forties, a number of turnpikes were projected for this county, and a few of them were actually built. White, speaking of them in his *Statistics of Georgia*, says: "The Unicoy turnpike road runs from North Carolina to Clarksville, forty miles, crossing the Blue Ridge. There is also a turnpike from Major Logan's, at Loudsville across the Blue Ridge through Tesnatee gap, seven miles long; which cost \$3,000. It pays a good interest on the investment, and is chartered for thirty years." These roads have all, since, passed out of the hands of the stock companies; and now they constitute a part of the public-road system of the county, kept up entirely by statute labor. The highways of Habersham at present are in a fair condition considering the hilly nature of the county, and the system, under which they are maintained. This is especially true of all the main thoroughfares, such as the Nacoochee, the Toccoa, the Tallulah and the Demorest roads. Were it not for the unusually steep grades of these several roadways, in places, they would compare favorably with the roads in the more level counties of the State. Each individual, subject to road-duty, is said to work, on an average, about six days per annum. Most of this time is put in, on general repairs, and but little work of a permanent nature is attempted. The result of this method of road-working is that the highways remain practically the same, from year to year.

The road-building materials of Habersham county are the usual crystalline rocks, common to the Crystalline area. The gneisses are the most abundant, and are most widely distributed. Trap rock (diabase) occurs in the vicinity of Toccoa and Tallulah. It is also reported to occur in other portions of the county; but it was examined only at the above named localities. One of the best exposures of this class of rock examined by the writer occurs in a cut on the Southern Railway about two miles northeast of Toccoa. The rock appears here in the form of four well-defined

dikes, one large, and three small ones. The smaller dikes, which vary from a few inches to three feet in thickness, are all well exposed in the cut ; while the large or main dike crosses the railroad in a fill near by, but is to be seen in a small ravine, a few rods south of the road, where it has a thickness of many feet. This main dike can be traced, as a more-or-less continuous outcropping, in a northwest direction for several miles. It is well exposed at Toccoa creek, a few miles northwest of Toccoa, where it gives rise to rapids in that stream. At several points along the line of outcropping between the Southern Railway and Toccoa creek, are many exposures, where the weathered boulders are so abundant, as to render the cultivation of the soil impracticable. The trap occurring in the vicinity of Tallulah seems to be the northwest extension of the dike. A microscopic study of the specimens of this rock taken from the dikes on the Southern Railway shows it to be a typical olivine-diabase. It varies from an exceedingly fine- to a medium coarse-grain. Some specimens show a slight tendency to a porphyritic structure, due to the presence of large, stout crystals of plagioclase; though most of the plagioclase crystals are small and needle-like.

The olivine is very abundant, and is often present in well formed crystals, which occasionally show an advanced stage of serpentinization. The specimens from the smaller dikes differ from the specimens taken from the larger dikes, only in having a finer texture or a closer grain. The rock is extremely difficult to break, and apparently possesses all the other qualities essential to a first-class road material. Its proximity to the railroad, together with its extent, makes the trap, here exposed, one of the most valuable deposits of this class of rock in the State.

WHITE COUNTY

Area, 170 square miles ; approximate road-mileage, 150 ; number of miles of graded road, 0 ; number of miles of macadamized road, 0 ; amount of money raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

White county is hilly, and the public roads often have steep grades. The road materials of this county are abundant. They consist of granites, gneisses and schists. There is also much gravel along the streams, well suited for road-surfacing. The roads are worked, on an average, only about five days each year; and they are frequently in bad condition, during the winter and early spring months.

The streams of the county are rapid, and are rarely bridged. The fords are generally rocky, and frequently dangerous, especially when the streams are swollen.

LUMPKIN COUNTY

Area, 267 square miles; approximate road-mileage, 250; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

Topographically, Lumpkin county is quite mountainous, and the cost of building roads of easy grades throughout its several districts would necessarily be very expensive. The majority of the leading thoroughfares were located, many years ago, during the early gold excitement in that region; and but little attention seems to have been given to the question of grades. In order to establish first-class roads in Lumpkin county, as well as in the majority of the other mountainous counties of North Georgia, it is essential, that the roads, in many cases, should be re-located. This would not only reduce the cost of construction, but it would at the same time greatly lessen the expense of maintenance. The several roads radiating from Dahlonega, the county-seat, were nearly all originally badly located, and, in most cases, they will probably remain unchanged. No modern practical highway-engineer would attempt any permanent improvement on these roads, until they are surveyed and re-located.

The clays of Lumpkin county, which originate chiefly from the

breaking down of the gneisses and schists, are usually of a red color. They make good roads, as long as they are dry and well drained; but, in the winter and early spring, they often become almost impassable.

The streams of the county are numerous and rapid. The larger ones are generally crossed by wooden bridges, which are not always kept in the best repair. The county at present owns one iron bridge, erected at a cost of \$3,500.

The roads of the county are kept up entirely by statute labor. They are worked, on an average, seven days each year; but much of this time is idled away.

The road-building materials are chiefly gneisses and schists. There is also, in some places, granite, which appears as intrusions, mostly in the form of small dikes. It is usually coarse-grained, and poorly suited for road-metal. The following is a description of two different varieties of schist, of very common occurrence in Lumpkin county, given by Dr. Thomas L. Watson, in the report on the Gold Deposits of Georgia:—¹

“No. 4. Locality—The dump-pile of the Moore and Cannon cut, Singleton mine.

QUARTZ-AMPHIBOLITE (*Hornblende-Schist*). This is a rather coarse-grained, dark-colored, speckled rock, with a decided schistose structure, when viewed from one side. Otherwise, it appears to be perfectly massive. Hornblende, quartz and pyrite are discernible, megascopically; the pyrite, however, only in occasional small particles.

Microscopically, the rock is composed principally of common green hornblende, quartz and epidote, with some pyrite and calcite. The hornblende is mostly prismatic and fibrous in outline, although allotriomorphic grains occur, in which both cleavages are well developed. The epidote occurs in irregular small grains, scattered through the interlocking quartz grains.

No. 27. Locality—An exposure along the road, at the Hand mine.

¹ Geological Survey of Georgia, Bul. No. 4—A, A Preliminary Report on a Part of the Gold Deposits of Georgia; pp. 324 and 327.

MICA (*Muscovite-Biotite*) -SCHIST. Megascopically, the rock is medium-grained, very light-colored, and rather finely banded. Quartz, muscovite and biotite are visible. Microscopically, the rock consists essentially of quartz, biotite and muscovite. Some feldspar, more or less altered, with numerous small grains of epidote, are found scattered through the section.

The two micas are intimately associated, and are present, in about equal proportions. Both are drawn out into long, narrow strips, which are grouped into layers, arranged in the direction of their longer diameters. The greater part of the rock is made up of quartz, which forms irregular-shaped grains."

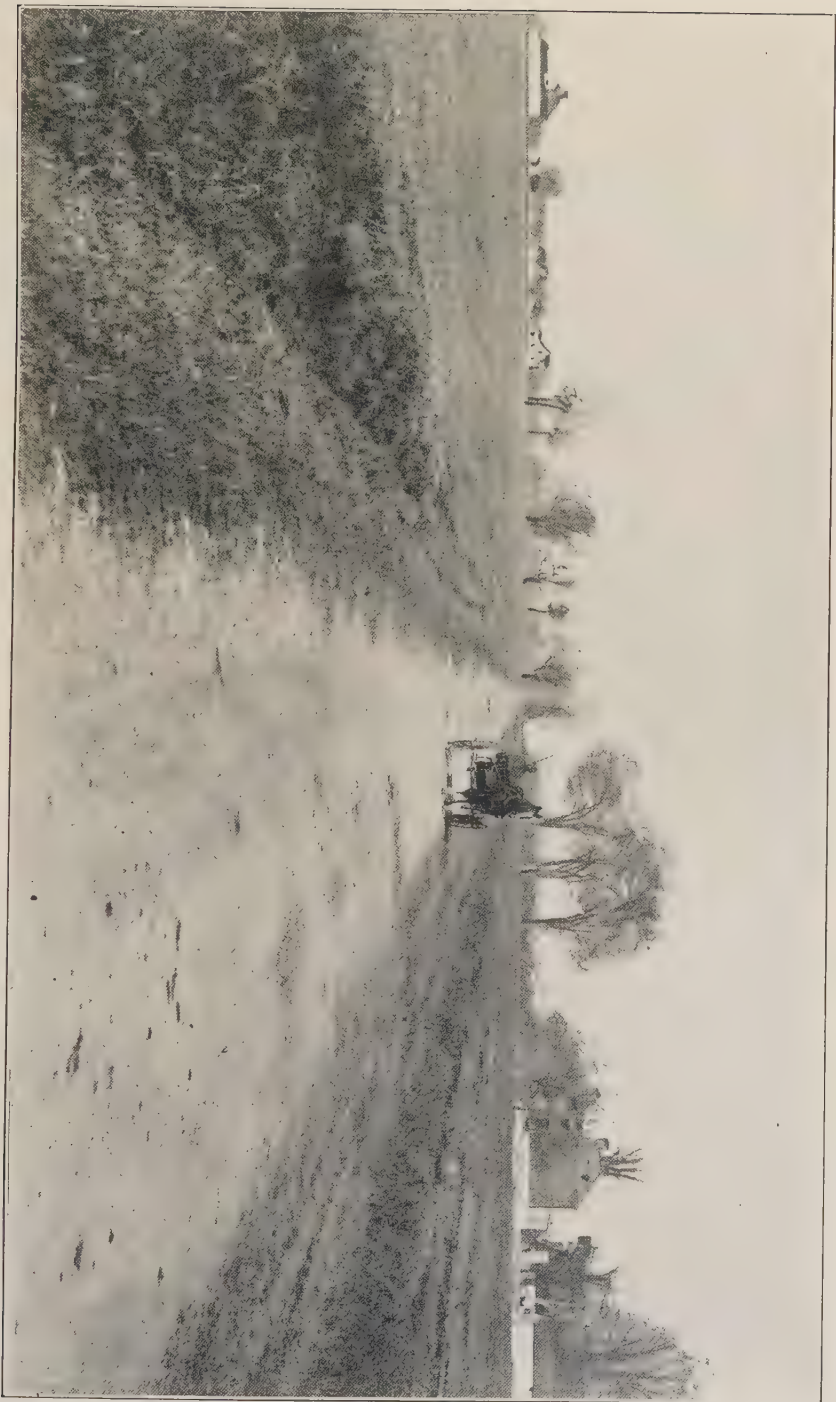
Both these varieties of schist are very abundant in the vicinity of Dahlonga. The former is often associated with gold-bearing rocks, and is called, by the miners, *brick-bat*, from its peculiar mode of weathering. It is very hard; and, when massive, it makes an excellent road material.

Gravel is found, more or less plentiful, in all the streams. Especially is this true of those streams, which have been worked for gold. In many places, there are to be seen great heaps of gravel, ready for use on the roadway.

DAWSON COUNTY

Area, 192 square miles; approximate road-mileage, 375; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, 0. Hands work, on an average, about nine days each year. The roads are constructed and maintained by statute labor.

Topographically, Dawson county is broken; and in places it becomes quite mountainous. The construction of first-class roads in the county will always be an expensive undertaking, on account of the cost of grading. The county is well supplied with granite, gneiss etc., suitable for road-surfacing. Hornblende-schist is quite abundant in this county; at many places, when decomposed, it gives rise to the red hills. Trap rock is reported.



THE SAND-BAR FERRY ROAD, RICHMOND COUNTY, GEORGIA.

at a number of localities in the county; but its extent and mode of occurrence have not been investigated. The roads of Dawson county, at the time of the writer's visits, were found to be in fair condition, for a hilly district. Some of the roads, in places, have very steep grades; but, in many cases, these difficulties could be overcome by re-locating the roads; while in others, expensive grading would have to be resorted to, in order to construct first-class roadways with easy grades.

The citizens of the county appear to be satisfied with the present system of road-maintenance; or, at any rate, the question of changing their plan seems not to have been generally discussed.

FORSYTH COUNTY

Area, 297 square miles; approximate road-mileage, 150; number of miles, of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

The roads of Forsyth county are worked, on an average, about five days each year; and, as a consequence, they are not always in first-class condition. The surface of the county is generally hilly, and the roads, in places, have steep grades. This defect, however, in many places, could be easily overcome by the re-location of the roads.

The road-building materials of the county consist of granites, gneisses, hornblende-schists and trap rock. The last named rock is said to be found in large quantities along the Chattahoochee river, in the eastern part of the county. It is also reported to occur in the northern part of the county.

The Ordinary, in speaking of the method of road-maintenance now in force, says: "Our roads are worked under the old road law. In my opinion, the new law would prove more satisfactory."

Forsyth county has constructed, in the last few years, three excellent iron bridges, at a total cost of about \$10,000.

HALL COUNTY

Area, 497 square miles; approximate road-mileage, 500; number of miles of road graded, 0; number of miles macadamized, 0; amount raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

The highways of Hall county, at the time of the writer's visit, were found to be in fair condition, considering the system, under which they are maintained. There appears to be considerable interest manifested throughout the county for the betterment of the highways; and it seems to be only a question of time, when the county will levy a special highway tax, and the roads will be kept up, by means of hired or convict labor. Dr. E. E. Dixon, Chairman, Board of Roads and Revenues, in speaking of the roads of Hall county, says: "Our present system is imperfect. We are trying to work up a sentiment to move up on a better system."

The road-building materials of Hall county are granite, gneiss, hornblende-schist and trap rock. The first three varieties of rock are quite abundant throughout the county; while the latter is limited to a few localities. One of the best exposures of trap rock in the county occurs on the old federal road about eight miles south of Gainesville, and five miles east of Flowery Branch. It occurs here in large quantities on the surface in the form of rounded boulders, which vary in size from a few inches to several feet in diameter. The rock is exposed at no place *in situ*. However, judging from the large number of boulders on the surface, the dike must be several feet in thickness. A similar dike, or probably a continuation of the same one, is exposed near the Southern Railway two miles south of Gainesville. The outcropping here is also in the form of boulders of disintegration, which are frequently of large size, and so abundant, in places, as to seriously affect the cultivation of the soil. A specimen of the rock (Museum No. 1,654), secured from this exposure, was shown by microscopic examination to be olivine-diabase, or a true trap rock, the best known material for road-surfacing. The rock is fine-grained and of a dark-gray

color, and consists of plagioclase, augite and olivine. Other exposures of trap rock are reported, both in the eastern and western part of the county; but they were not examined. The trap dike, spoken of above, near the city limits of Gainesville, seems to offer an excellent opportunity for that city to secure the best of material for street macadam at small cost.

BANKS COUNTY

Area, 359 square miles; approximate road-mileage, 200; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money raised annually for public-road purposes, 0. The roads are constructed and maintained by statute labor; and hands work, on an average, three days each year.

The highways of Banks county are reported by the Ordinary, Mr. T. F. Hill, to be in poor condition. It is practically impossible to maintain first-class dirt roads, in any hilly section of the country, like Banks county, by statute labor, when the number of working days is so small.

Road materials are abundant in Banks county. They consist of granite, gneiss and probably trap rock. The latter, however, has not been examined; though it has been reported to occur in several localities.

FRANKLIN COUNTY

Area, 359 square miles; approximate road-mileage, 300; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

Franklin county lies wholly within the Crystalline area. The surface is rolling, and the soils are mostly clays. The roads are generally in fair condition, considering the method, under which they are maintained.

Road-building materials are plentiful. They consist mainly of granites, gneisses and trap rock. The granites and gneisses are often fine-grained, and well-suited for road-surfacing.

Trap rock occurs in a large, more or less continuous dike, traversing the county in a northwest-and-southeast direction. This dike seems to be a continuation of the one intersecting the Southern Railway near Toccoa. Good exposures of it are to be seen four miles northeast of Carnesville, on the road leading to Lavonia; also, on the Elberton Air-Line Railroad, two miles northwest of Martin station. Between these two points, are numerous other outcroppings, where the rock occurs in considerable abundance in rounded boulders in the woods and cultivated fields. The thickness of the dike varies from a few yards to several rods. Near the main dike, are to be seen, in places, small dikes running parallel with it. The smaller ones are often only a few inches in thickness.

The following is a description of a specimen of the rock, taken from the largest dike:—

Museum No. 1,655 — *Olivine-Diabase*.

Locality—Seven miles northwest of Carnesville, on the public road to Toccoa.

Megascopically, this is a rather coarse-grained, dark-gray rock, in which the needle-like crystals of plagioclase are quite conspicuous. There is also to be seen on a fresh fracture large angular grains or imperfect, glistening crystals of plagioclase, which give to the rock a somewhat porphyritic structure. Microscopic examination shows, that all the original mineral constituents, with the exception of magnetite, have commenced to undergo alteration. Many of these plagioclase crystals are more or less completely kaolinized. The augite is undergoing uralitization, or changing into hornblende; while the olivine has been converted, in a great measure, into serpentine. A few plates of biotite were noticed in the section.

HART COUNTY

Area, 381 square miles; approximate road-mileage, 400; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road pur-

poses, \$2,500. The roads are constructed and maintained by statute and free hired labor.

The surface of Hart county is generally much broken ; and the cost of constructing first-class highways with easy grades is necessarily great.

The materials of the county for road-building are abundant and quite generally distributed. They consist of granite, gneiss, hornblende-schist and trap. The last-named rock is reported as occurring at several localities in the county in large quantities.

The roads are at present being kept up by means of statute and free labor. They are reported to be in fair condition. The county levies a special tax, of one mill on the dollar, for road purposes. The amount collected from this source is about \$2,500. This amount is used for the payment of hands employed on the roads. Each person, subject to road-duty in Hart county, is required to pay a commutation-tax of \$1.60, or work on the public roads four days annually. The present system of road-working in this county has been in operation only a short time, and its merits have not yet been tested.

ELBERT COUNTY

Area, 406 square miles ; approximate road-mileage, 600 ; number of miles of graded road, several ; number of miles of macadamized road, 0 ; amount of money annually raised for public-road purposes, not ascertained. The roads are constructed and maintained by statute and convict labor.

Elbert county lies in the northeastern part of the State, wholly within the Crystalline area. Its surface is usually rolling, and the highways in places have steep grades. The crystalline rocks suitable for road purposes including granites, gneisses, trap etc., common to the Crystalline area, are both abundant and widely distributed. Typical specimens of the granite, which occurs in this county, may be seen at the quarries near Elberton, where the stone is extensively worked for monumental and building purposes. The stone is medium fine-grained, has great strength, and is well suited

for macadam. Trap rock is reported as occurring at several localities in the county; but it was examined at only one place, namely, on E. B. Heard's property near Blue Branch, some seven miles east of Elberton. The trap occurs here in two small dikes, neither of which has a thickness of more than four feet. Both dikes are well exposed in the embankment on either side of the public road. They are only a few feet apart, and correspond in dip and strike to the enclosing gneisses and schists. These dikes can be traced for some distance through the cultivated fields, by the weathered, rounded boulders lying on the surface.

A specimen of the trap rock (Museum No. 1,603), taken from the exposure on the roadside at Blue Branch, is a fine-grained, dark-gray, olivine-diorite, weathered into the usual characteristic rounded form. The individual minerals are difficult to make out, without the use of a lens. Examination in thin sections under the microscope, shows an unusually large amount of olivine, which, in places, has partly altered into serpentine. The plagioclase occurs in the form of long needles and as short stout crystals. The latter are not abundant. The augite is present in the form of plates and irregular masses, filling up the interstices between the feldspar crystals. It rarely shows any distinct cleavage lines. Magnetite and chlorite are both present. The former mineral occurs in considerable abundance, usually as crystals. It would be a difficult matter, to find a rock better suited for road-surfacing than the trap here described.

Another rock (Museum No. 1,627), well-suited for road-purposes, occurs at the Pearl cotton-mills, six miles east of Elberton. This is a medium fine-grained, dark-green, massive diorite, with a few large, conspicuous crystals of green hornblende. The other minerals are indistinguishable by the unaided eye. Microscopically, the rock is seen to be made up of hornblende, feldspar and quartz, with a few scattering grains of epidote and chlorite. The hornblende is very abundant, making up fully 90 per cent. of the entire rock mass. It occurs mostly in the form of irregular crystals, which often show prismatic cleavage. Both the green and brown

varieties are present. The former is massive and resembles very closely the chlorite, with which it is always associated. The feldspar and the quartz, which are very unevenly distributed throughout the section, occur as irregular grains. Magnetite and pyrite are both present; neither, however, is abundant. This rock, which appears in the form of a huge dike or intrusive mass, is very abundant in the vicinity of the Pearl cotton-mills, where it gives rise to the fall, that furnishes the power for operating the mill. The rock in places is slightly schistose. Otherwise, it is an ideal road-material.

Elbert county has recently adopted the new road law; and now it regularly employs, on an average, about 25 convicts on its highways. The cost of maintaining the chain-gang, together with the other expenses connected with the present system of road-working, is met by the assessment of a special road-tax of one mill on the dollar on all taxable property, and a commutation-tax of \$2.00 on each individual subject to road-duty. The rated money-value of a day's labor, in settlement of the commutation-tax, is placed by the County Commissioners at 25 cents.

The road-equipment of Elbert county consists of two Champion road-machines, wagons, scrapers, 15 mules etc. There is considerable interest manifested throughout the county in the improvement of the highways; and it is thought, that the present system will give general satisfaction.

MADISON COUNTY

Area, 300 square miles; approximate road-mileage, 500; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

Madison county has an abundance of granite, gneiss, schist etc., suitable for road material. Trap rock is also reported as occurring in different parts of the county; but the localities were not visited by the writer. The roads of the county are said to be in fair con-

dition. They are worked, on an average, about six days each year by the road-hands. The surface of the county is hilly, and the grades of the roads are often steep.

JACKSON COUNTY

Area, 382 square miles ; approximate road-mileage, 328 ; number of miles of graded roads, 0 ; number of miles of macadamized roads, 0 ; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

Topographically, Jackson county is hilly, and the public roads frequently have steep grades. The rocks suitable for road materials are granite, gneiss, hornblende-schist, diorite and trap. The three first named varieties of rock are widely distributed throughout the county, and are frequently well exposed on the sides of many of the leading thoroughfares. The general distribution of these rocks reduces to a minimum the cost of placing them on the roadbed.

Good exposures of diorite are to be seen in this county on the Athens road about eight miles south of Jefferson. It occurs here in a belt several feet in thickness, interlaminated with the schist. The rock is massive, dark-gray, and has a uniform texture. In the natural outcropping, there is to be seen a slight tendency toward schistose structure. This structure, however, is not noticeable in hand specimens.

Microscopically, the rock is seen to be made up of green hornblende, feldspar and a sprinkling of quartz. The hornblende is the most abundant constituent. It is present as large irregular plates and imperfect crystals. The latter often exhibit distinct prismatic cleavage. The feldspar is well preserved and distinctly striated. Trap rock is reported at several places in the southern part of the county.



ROCK QUARRY AT THE HEAD OF THE CANAL, NEAR AUGUSTA, GEORGIA.

GWINNETT COUNTY

Area, 450 square miles ; approximate road-mileage, 400 ; number of miles of graded road, 0 ; number of miles of macadamized road, 0 ; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

Gwinnett county is located near the center of the Crystalline area in the northern part of the State. Its surface is hilly. The road materials consist mainly of gneiss and trap rock. The former rock, which is similar to the Lithonia gneiss, is reported, by Dr. Thos. L. Watson, Assistant Geologist, to occur in large quantities in the vicinity of Snellville, Rosebud, Loganville and Winder. This is a light-colored, fine-grained contorted gneiss, fairly well suited for road-surfacing. Dr. Watson also reports the occurrence of trap rock, in the form of a large dike, within the corporate limits of Lawrenceville. This rock is said to be found at other places in the county ; but its extent has not been investigated. The schists, both the mica and the hornblende varieties, are widely distributed throughout the county. The latter will doubtless be found of value in road-surfacing in many localities. Massive quartz, resulting from the breaking down of quartz veins, is also of common occurrence.

MILTON COUNTY

Area, 115 square miles ; approximate road-mileage, 75 ; number of miles of graded road, 0 ; number of miles of macadamized road, 0 ; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

The surface of Milton county is usually hilly, and the cost of constructing good roads with easy grades is expensive.

The County Ordinary says : " We have our roads worked, and they are in very good shape, at this time. We have some steep grades, that could be helped considerably by being graded down ; and we are expecting to do some work in that direction soon. I

am satisfied, we could get our people interested in the improvement of our public highways, so that they would put in full time at work, while on the roads. The result would be very gratifying, and, in a short time, all our leading thoroughfares would be greatly improved."

The road-building materials are abundant, and quite generally distributed throughout the county. The most common are the granites, gneisses and schists. Diorite, and possibly trap rock, is also found.

COBB COUNTY

Area, 379 square miles; approximate road-mileage, 300; number of miles of graded road, 10; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute and free labor.

The roads of Cobb county are kept up mainly by statute labor; but each year there is also a limited amount of grading and general road-improvement carried on, by means of hired labor. The expense for the hired labor is paid out of the general county fund, there being no special road-taxes levied. The most of the grading so far done is in the vicinity of Marietta, where the roads in places have been greatly improved, by cutting down the hills and lessening the grades. It is thought, that this method of working the highways will become general throughout the county, when the people more fully understand its improvement over the old system.

The road-building materials of Cobb county are plentiful, and quite generally distributed. They consist of granites, gneisses, hornblende-schist etc. A good quality of granite, suitable for road-surfacing may be seen at the Hames quarry on the east side of Kennesaw mountain. The rock is a fine-grained, light-colored granite, made up largely of quartz. The feldspars are fresh and undecomposed, a condition characteristic of all light, durable granites. The hornblende-schists and diorites are very common in Cobb county. They give rise to the red soil, so commonly met

with throughout the county. All these schists, when not too distinctly laminated, make excellent material for road-surfacing. This class of rocks is exposed in many of the cuts on the Western & Atlantic Railroad between Marietta and Acworth. Another variety of rock, which has a considerable local use for road-surfacing, is a saccharoidal quartz, occurring within the corporate limits of Marietta. It is well exposed, in the excavation near the National Cemetery, where it has been more or less extensively quarried for the drive-ways in the cemetery. The rock occurs in layers, varying from a few inches to a foot or more in thickness; and it has all the appearance of a highly metamorphic sandstone. It is granular, and easily crushed into a coarse sand, which makes an excellent surfacing-material, for side-walks and drive-ways. A large exposure of a similar rock occurs on the Western & Atlantic R. R., a short distance south of Vining station.

Trap rock is reported, as occurring in the northern part of the county; but the locality has not been visited. Massive quartz, resulting from the breaking down of quartz veins, is frequently abundant in the cultivated fields. It has had a limited use for filling quagmires.

DOUGLAS COUNTY

Area, 178 square miles; approximate road-mileage, 150; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

The surface of Douglas county is generally hilly; and the roadways in places have steep grades. The main thoroughfares of the county are in a fair condition for common earth roads, considering the system, under which they are maintained. The best roads in the county are probably those in the vicinity of Lithia Springs, where they are used more or less for pleasure drives by the guests of that famous resort. These roads usually have fair grades; but in places they are quite sandy. This defect, however, could

be easily overcome by crowning the roads and covering their surfaces with a thin layer of clay, which is everywhere present. These sands, which are also frequently seen in the roadways in the vicinity of Villa Rica, have originated from the disintegration of a medium coarse-grained gneissoid granite, which is found, more or less abundant, in several localities throughout the county. Besides these gneissoid granites, there are also many other rocks, which would make fair material for road-surfacing. Probably the most valuable of these rocks for road purposes is the quartz-diorite, occurring in the vicinity of Winston. This rock weathers into a red saprolite, which may be seen in the fields as fertile soil, immediately north of the Winston depot. Specimen No. 1,577 of the Museum catalogue, was obtained from a cut on the Southern Railway, about half-a-mile west of Winston, where the rock is exposed to the depth of 20 feet or more. The rock at this exposure is more or less schistose, and so decomposed, that it is difficult to get even a hand specimen sufficiently fresh for microscopic study. The rock is dark-gray; and it is occasionally traversed by parallel seams of light-colored quartz, which give to it a laminated appearance. The texture of the rock is so fine, that it is difficult to make out, by the unaided eye, any of the different mineral constituents except hornblende. Microscopic examination of the rock in thin sections shows it to be made up of hornblende, quartz and plagioclase, with magnetite, pyrite and chlorite as minor accessories. The hornblende is the most abundant constituent. It occurs in irregular, elongated masses, with their longer axes parallel. This rock, which is met with at several places in the county, would make an ideal road-surfacing material, if it were not so distinctly laminated.

CARROLL COUNTY

Area, 549 square miles; approximate road-mileage, 600; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road pur-

poses, o. The roads are constructed and maintained by statute labor.

The surface of Carroll county is generally rolling, and the soils are mostly clayey ; but in certain districts, which are traversed by belts or zones of granite, the soils partake of a sandy nature. The soils of the last named character extend over a considerable area in the vicinity of Villa Rica, where the public roads are often somewhat sandy. As a general rule, the soils of the county might be said to be favorable for the construction of dirt roads. The surface of the county, though undulating, presents no difficult problem in locating roads of easy grade. Many of the roads, in places, at present have steep grades. However, this defect, in most cases, can be easily corrected at a small cost by re-locating the roads.

The road materials of Carroll county, which consist of gneisses, granites, schists and trap, are all, except the last named rock, abundant and widely distributed. Trap rock was found at only one place in the county, namely, near the Chattahoochee river a short distance north of Whitesburg. The rock occurs strewn about the cultivated fields in limited quantities, and evidently comes from a small dike traversing that part of the county. It is more than probable, that the dike, from which these float-boulders are derived, is the northern extension of the large dike traversing Coweta, Meriwether and Talbot counties.

The public roads of Carroll county are kept up at present by statute labor ; but it was learned, that this system is soon to be abandoned, and a special tax raised, for maintaining the highways. Carroll county has erected no steel or iron bridges, owns no road machinery, and has apparently done but little toward making improvements of a permanent nature on its public ways. For the last few years, the roads have been worked, on an average, of only about five days per annum ; and, as a consequence, they are not in the best condition.

CAMPBELL COUNTY

Area, 230 square miles ; approximate road-mileage, 250 ; number of miles of graded road, 0 ; number of miles of macadamized road, 0 ; amount raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

The Chairman of the County Commission of Roads and Revenues of Campbell county, in speaking of the condition of its roads, says : "We have just such roads as we had 100 years ago ; or rather, 100 per cent. worse, because we have 500 per cent. more vehicles to travel over them." Many of the leading public-spirited men of the county have become very much dissatisfied with the present system of road-working ; and the time seems to be near at hand, when a different method of road-improvement will be adopted. A gradual improvement of the roads, by taxation, is strongly advocated by the Chairman of the Board of Commissioners. The first roads to be improved, according to his plan, are the principal highways of travel, radiating from the county-seat. These are to be gradually extended to the county-line or to the chief centers of trade, after which the roads of lesser importance are to be improved, in like manner.

Campbell county lies wholly within the Crystalline area ; and, as a consequence, it has an abundance of granite, gneiss etc., suitable for road-surfacing.

FULTON COUNTY

Area, 166 square miles ; approximate road-mileage, 300 ; number of miles of graded road, 140 ; number of miles of paved and macadamized road, 85 ; amount of money annually expended on the highways, from \$75,000 to \$140,000. The roads are constructed and maintained by convict and statute labor.

Fulton county has done more in the last few years toward the betterment of its highways, than any county in the State. Other counties may justly lay claim to a greater mileage of improved highways ; yet none can equal Fulton in the excellence of the

construction and the durableness of its roadways. Such thoroughfares as the Peachtree and Manchester roads are ideal roadways, not only for traffic, but also for pleasure driving, and for wheelman as well. The construction of these roads, together with several other similar roads, radiating from the city of Atlanta, has cost the county, in the aggregate, more than half-a-million dollars. This seems to be a large sum of money to expend in the construction of less than a hundred and fifty miles of roadway. Nevertheless, if the high class of roads constructed is taken into consideration, and also the uneven or hilly surface of the country, through which they pass, it will be seen, that the money has not been lavishly expended.

Many of these roads required an immense amount of grading, which, in some instances, cost more than \$10,000 per mile. They are all amply wide, varying from forty to sixty feet and having gentle grades. The side drains, in places, are paved with stone, and the culvert and cross drains or water-ways are constructed of granite or the best hard-burnt tile. The hardened surfaces, which vary from 7 to 12 inches in thickness, are often forty feet wide. This gives more than 20,000 superficial square yards of road-surface per mile, and explains, in a measure, the unusual cost of the roadways. Much of the materials, with which these roads were surfaced, was chert, brought from Northwest Georgia or Alabama; and, in some instances, it had to be hauled considerable distances by wagons and carts before it was laid down on the roadway. The cost of the chert alone, used on the Manchester road, which has a total length of six and a half miles, was more than \$50,000.

The present system of improving the highways of Fulton county by means of convict labor was inaugurated in 1876 by Judge Daniel Pitman, then County Ordinary. At that time, all the main thoroughfares radiating from the city of Atlanta, as well as many of the principal streets, were in a deplorable condition for traffic, during the winter and early spring months. One writer, in speaking of the condition of the streets and roads during that time, says: "There were places in the center of the city, where a four-horse-

team could not pull a light wagon; and what was true of the city, was still more so of the country." To ameliorate these conditions, Judge Pitnan organized the first chain-gang, of fifteen convicts. This small and inadequate force was unable to do much, at first, except to carry on general repair-work. Nevertheless, the experiment demonstrated the practicability of this method of road-improvement. The system soon grew in favor; the working force was gradually increased; and improvement of the highways at the same time became of a more permanent and lasting nature. Thus, from an insignificant beginning was evolved the present very complete and perfect system of highway-improvement.

The Fulton chain-gang, as now organized, consists of about 350 convicts. These convicts are under the direct management of a superintendent, appointed by the County Commissioners. The superintendent, in turn, appoints all the overseers, guards etc.; and he is held solely responsible by the Commissioners, for the condition of the force of convicts under his charge; and, also, for the efficiency of the work executed. The following table shows the number of employees of the Department of Public Works of Fulton county, exclusive of the convicts for March, 1899, together with the salary of each per month:—

1 Superintendent	\$ 166.70
1 Assistant Superintendent.	100 00
1 Book-keeper.....	65.00
3 Overseers.	60 00
1 Woodsmith and Foreman	75.00
1 Blaster and Foreman	60.00
3 Blacksmiths.....	50.00
31 Guards.....	37 50
34 Teamsters.	20 00

The amount of money annually expended upon the public roads of Fulton county depends, in a great measure, upon the amount paid for surfacing material. Last year, the total sum paid out for all purposes aggregated approximately \$90,000. This estimate would probably be an annual average of the expenditure on highway-improvement for the last few years. The actual cost of main-



THE COLUMBUS ROAD NEAR MACON, GEORGIA.

taining each convict, including board, clothing, guarding etc., is placed by the superintendent at \$12.00 per month. Many of the convicts are hired from other counties.

The subsistence account of each convict, as shown by the annual report of the superintendent for 1899, was only $8\frac{1}{4}$ cents per day. This appears to be an unusually low allowance for laboring men engaged in hard work; yet it must be borne in mind, that the greater part of the foodstuffs consumed are raised upon the convict farm, and the price placed upon them is the actual cost of production. In speaking of the economic importance of this well regulated and judiciously managed farm, Superintendent Donaldson says: "We produce on it much we eat, and in a word, if a wall was built around us, we would have nearly all of the requirements for a comfortable living."

Besides the farm, together with its necessary equipment, Fulton county owns the following outfit used in highway-improvement:—

Carts	152
Derricks (10-ton)	2
Horses	3
Mules	161
Plows	7
Rollers (steam, 10-ton)	2
Road-machines (Champion)	2
Road Sprinklers	1
Rock-crushers (Champion)	2
Tools (Quarry)	2 sets
" (Woodworking)	1 "
" (Blacksmithing)	3 "
Tents	16
Wagons	66

In working the roads, the chain-gang is usually divided into two or more camps, which are moved from place to place as the work requires. In addition to these movable camps, there is a permanent camp, or what is called the county barracks, located on the convict farm, where the convicts are housed during the winter. These barracks are well constructed, and have all the conveniences of a well regulated prison.

In addition to the chain-gang, Fulton county also employs statute labor on its highways. All persons, subject to road-duty, are required to work the road five days each year, or pay a commutation-tax of \$2.50. Many of the less important roads, in the remote parts of the county, are kept up entirely by statute labor.

All the hardened ways, so far constructed by the Fulton county chain-gang, may be divided, for convenience of description, into three classes, namely, the macadamized road, the chert road and the rubble-stone road.

The *Macdamized Roads*, as they are now being constructed by the convicts, consist of four layers. The first or bottom layer, which has an average thickness of four or five inches, is made of broken stones, having a diameter, in their greatest dimension, of about four inches. These stones usually consist of field-stone, or some other inferior rock, taken from the roadbed in grading. As the stone is removed from the excavation, in grading, it is generally distributed along the prepared roadbed, and broken by hand to the desired size. The stones of the second layer are reduced to $2\frac{1}{2}$ inches in diameter. This layer has a thickness of about 3 inches, when compressed by rolling. The stone used in this layer is generally more durable than that used in the basement layer, and is commonly prepared by the rock-crusher. The third layer has about the same thickness as the second; but the stones, of which it is formed, are reduced to $1\frac{1}{2}$ inches or less in their greatest diameters. This layer is thoroughly compacted by passing over it a number of times a 10-ton roller, after which the fourth and last layer, consisting of screenings, is added. This, in turn, is rolled and sprinkled, until it becomes hard and smooth. A hardened way, when thus constructed of good material, makes an excellent roadway, which, under proper care, should last for several years.

The *Chert Roads* are surfaced entirely with chert. This material is generally put down, in two or more layers, and is thoroughly compacted by rolling, until its total thickness is reduced to eight or ten inches. The chert used on the Fulton County roads, was

unscreened ; and, as a consequence, the surface has, in places where there has been much wear, become rough and uneven. These roughened and bumpy surfaces have become quite noticeable, in places, both on the Peachtree and the Manchester road.

The Rubble-stone Road, as constructed by the Fulton County chain-gang, consists of a pavement of broken stone, similar to the rubble foundation of the Telford road.¹ The surface of this class of roadways is always rough and uneven ; yet they are quite durable. Where these paved ways have been constructed in Fulton county, the broken stone generally covers only about one half of the roadway, the remaining part being a well crowned earth-road, which is almost universally used during dry weather.

The macadamized road, as described above, is the only class of hardened ways now being constructed in Fulton county. This class of roadway is undoubtedly the most economical, so far constructed in the county. They are less dusty, by far, and are more durable than the chert road, and, at the same time, smoother and more suitable for all kinds of travel, than the rubble-stone road.

The road-building materials occurring in Fulton county are chiefly gneiss, hornblende-schist and diorite. A diligent search has been made by the writer, from time to time, for trap dikes ; but, so far, they have not been located in the county. They probably exist ; however, they must be of small size, or they would be more conspicuous at the surface. The so-called trap rock, which occurs more or less abundant throughout the county, has been found, upon microscopic study, to be diorite or hornblende-schist, a rock somewhat resembling trap (diabase), but differing from it mainly in having hornblende, as one of its chief constituents, in place of augite.

The most abundant and widely distributed of the above named road-building materials are the gneisses. These rocks, differing only from the true granites in being laminated, are fairly well suited for road-surfacing, by reason of their toughness.

Typical specimens of this class of rocks are to be seen at a quarry

¹ See pp. 14, 43 and 44.

in the Cotton States and International Exposition grounds; also at the city stockade, a short distance east of Grant Park. These rocks, technically known as biotite-gneiss, are very plentiful in the vicinity of Atlanta; and, for many years, they have been more or less extensively used, in the construction of the foundation of buildings and retaining-walls, as well as for street macadam. These gneisses are either of a light- or dark-gray color, and are frequently more or less distinctly banded, owing to the segregation of the feldspar, quartz and mica along parallel lines. The chief mineral constituents are biotite, feldspar, quartz and epidote, all of which are readily distinguishable by the unaided eyes. The biotite is quite abundant, forming the greater part of the entire rock-mass. It occurs, mostly in the form of elongated plates and shreds, with their longer axes parallel. Intimately associated with the biotite, and frequently indistinguishable from it, by the unaided eye, there often occurs a limited amount of hornblende. This mineral is especially abundant in the dark-colored gneisses, quarried at the city stockade. The quartz and feldspar of the gneisses are present, as irregular grains and imperfect crystals. Occasionally the feldspar crystals attain a diameter of a quarter of an inch, or more, and thus give to the rock a porphyritic structure. When the epidote is as abundant, as in the stone quarried at the Cotton States and International Exposition grounds, it gives to the stone a peculiar greenish-yellow tint.

All these gneisses are usually fine-grained, and make a fair road-surfacing material. Their durability for macadamizing purposes is well demonstrated by their use, for several years past, upon the streets of Atlanta. Portions of the pavement of Washington street, in this city, formerly constructed of this stone, still remain in fair condition, after constant wear for twelve or fourteen years.

DESCRIPTION OF SPECIMENS.—The following notes are descriptions of specimens of diorite and hornblende-schists, suitable for road material, occurring in Fulton county:—

Museum No. 1,575. Locality, the Adamsville road, six miles west of Atlanta. *Quartz-Diorite*. Megascopically, this is a fine-grained

dark-gray schistose rock. The mineral constituents, on account of fineness of texture, are not easily distinguishable by the unaided eye. Microscopically, the rock is seen to be holocrystalline. It is made up chiefly of green hornblende, quartz and plagioclase. The hornblende is the most abundant constituent. It occurs in the form of elongated, parallel masses, and as imperfect crystals with prismatic cleavage. The quartz consists of irregular grains with their longest axes usually more or less orientated in the direction of the schistosity. Pretty evenly distributed throughout the section, are to be seen numerous imperfect crystals of plagioclase, which are usually quite fresh and distinctly striated. Magnetite, pyrite and epidote occur as accessory minerals; but none are very abundant. This rock is well exposed in a cut on the Adamsville road at the above named point. The rock is very difficult to break, and is well adapted for road-surfacing.

Museum No. 1,631. Locality, Lakewood. *Quartz-Diorite*. This rock is exposed in a cut on the recently graded road on the west side of the old city water-works reservoir at Lakewood. It occurs in layers eight or ten feet in thickness imbedded with the schists. The diorite is a dark-and-white-speckled rock, with numerous light-colored bands, which give it a schistose structure. The texture is fine-grained. However, the hornblende and feldspar are easily recognized, by the unaided eye. The banded structure is due mainly to the arrangement of the quartz along parallel lines.

Microscopic examination shows the rock to be made up of hornblende, plagioclase and quartz, with a few scattering grains of epidote. The hornblende is of a brown color. It occurs in large imperfect crystals, frequently exhibiting well-marked cleavage lines, and often enclosing small grains of epidote. The plagioclase consists of large irregular grains indistinctly striated. This rock has been used to a limited extent for street macadam, for which purpose it is admirably suited by reason of its great toughness. Other exposures of diorite are to be seen on University Avenue between Clark University and Lakewood.

Museum No. 1,645. Locality, Manchester road, near East Point.

Hornblende-schist. Megascopically, this is a dark-colored, fine-grained, slightly schistose rock. Hornblende, quartz and pyrite are all easily made out, without the use of the lens. The quartz is mostly distributed along fine, parallel lines, and gives the rock a somewhat indistinct banded appearance, when it is broken at right angles to its schistosity. The pyrite, which rarely shows crystal faces, is pretty uniformly diffused throughout the rock mass. It also occurs along the parting planes and in incipient fissures or cracks.

Microscopic examination shows the rock to be made up of hornblende and quartz, with magnetite, pyrite, and a few scattering crystals of feldspar, as accessory minerals. The hornblende, which is the most abundant constituent, consists largely of more or less imperfectly formed crystals, slightly orientated, and often exhibiting beautiful prismatic cleavage. Its color by transmitted light is brown, with a faint tint of green. The quartz occurs as irregular angular grains, frequently interlocking, and often arranged with their longer axes more or less parallel. The larger quartz granules contain many perfectly formed, minute crystals, which are taken to be epidote.

Magnetite occurs in considerable abundance, both in the form of crystals and granules. It is distributed pretty evenly through the section; and it also occurs as segregations along definite lines. The rock, here described, is one of the most common rocks in Fulton county. It usually occurs in the form of more-or-less extensive beds, interlaminated with the gneisses and mica-schists, and is always well exposed, in the cuts of the several railroads radiating from the city of Atlanta. It differs from diorite in being more completely laminated, and in containing little or no feldspar. Both the diorite and the hornblende-schists, when the latter is not so distinctly laminated, possess about equal merit as road-metal. They rank in durability next to trap (diabase); and in all cases, where they can be obtained at reasonable cost, they should be used in preference to the granites and gneisses.

Besides the above named rocks, suitable for road-surfacing ma-

terial, might be mentioned *massive quartz* and *mica-schist*. The former, which has been used to a limited extent for road-metal in different parts of the county, has resulted from the breaking down of the quartz veins in the gneisses and schists. This very hard, but at the same time, brittle rock possesses little or no binding power. It makes a fair road material; but it should never be used, when other material is at hand.

Mica-schist is very abundant in the county; and, like the massive quartz, it has had a limited use in road-construction. A good example of this class of rock may be seen at the quarry, recently opened on Peachtree creek, near the pumping-station of the city water-works. The rock quarried here has been used, to some extent, in the city of Atlanta, for macadamizing purposes, but chiefly as a top-dressing. It is a very peculiar stone, resembling a sheared diabase. The color on a polished surface is jet-black. The fresh fracture shows a dark-gray color with a brownish tint. The texture is usually fine, none of the original minerals being made out without use of the lens. The secondary minerals, quartz, calcite and chlorite, are frequently quite conspicuous along shearing-planes. Hand specimens of the rock, when taken from certain portions of the quarry, might be misjudged for massive rock. However, when examined in large masses or in the quarry, it is seen to possess a well defined schistose structure.

Microscopic examination of a section of this rock shows it to be made up of biotite and quartz with calcite, chlorite, pyrite and a few scattering grains of feldspar as accessory minerals. The quartz occurs as small angular grains, more or less orientated, and polarizing in gray colors. The biotite has a light-brown color, and is distinctly pleochroic. It is in the form of shreds or elongated plates, with their longer axes parallel. The section, in places, shows beautiful microscopic folds and contortions. The main defects of mica-schist in road-surfacing, is a lack of binding strength.

DEKALB COUNTY

Area, 269 square miles; approximate road-mileage, 320; number of miles of graded road, 35; number of miles of macadamized and paved road, 18; amount of money annually raised for road purposes, \$8,000. The roads are constructed and maintained by convict and statute labor.

DeKalb county has made considerable progress in the last few years toward the betterment of its highways. The present system of working the misdemeanor convicts on the roads seems to give satisfactory results, and meets with the general approval of all the leading citizens. The chain-gang, as now organized, consists of 35 convicts, under the management of a superintendent and a foreman. The superintendent has general control of all the employees on the public roads, and directs the work. He is also required to make reports to the county authorities, from time to time, of the progress of the work, and the expenses incurred. For his services, the superintendent receives \$60 per month; while the foreman, who has the immediate charge of the convicts on the road, is paid \$30 per month. There are also regularly employed one watchman and two guards. The latter are each paid \$30 per month, and the former \$25. The cost of maintaining each convict, including board and clothing, is placed at \$3.40 per month.

It is the aim of the present plan of road-improvement, to have the convicts repair all the main thoroughfares in the county at least once each year, and at the same time to do considerable work of a permanent nature in the way of grading and macadamizing. In addition to the chain-gang, all persons subject to road-duty work from two to five days each year on the public roads. Many of the second-class or less important roadways are kept up almost entirely by statute labor.

The equipment for road-working owned by DeKalb county is quite complete, and cost originally several hundred dollars. It consists of 1 Western road-machine, 1 portable rock-crushing plant (Champion), 10 wagons, 6 carts, several plows, 6 wheeled scrapers, 22 mules, a camping outfit, blacksmith's tools, etc.



A TRAP DIKE IN A CUT ON THE MACON BRANCH, GEORGIA RAILROAD, NEAR ROBERTS STATION, GEORGIA.

The hardened ways, so far constructed in DeKalb county, consist of macadam and rubble-stone roads. The latter are made 12 feet wide, alongside of which is an earth-road about the same width to be used in dry weather. The road leading from Decatur to Atlanta along the Georgia Railroad is constructed after this plan. It has been in use for several years; and it still remains in fair condition. The hardened ways, as now constructed, are made of broken stones after the macadam method. This class of road is much cheaper and more satisfactory than the rubble-stone road; and they will no doubt, in the future, be constructed throughout the county, wherever hardened ways are desired.

The materials for building such roads are very abundant, and are widely distributed throughout the county. They consist of granites, gneisses, hornblende-schists, diorite and trap (diabase). A typical granite of this county is to be seen at Stone mountain, where large quarries have been operated for many years. This stone is largely used for building purposes, and for street pavement. It has also been used to a limited extent for road-surfacing. The stone is a medium fine-grained muscovite-granite. A stone, very similar to this in mineral composition, but differing from it in being highly contorted throughout the mass, is to be seen at Lithonia. It also has an extended use for building and street purposes. The abundance of these stones, and the ease, with which they can be quarried, make them very important road-building materials, not only for DeKalb county, but for some of the adjoining counties, as well.

The diorite and the hornblende-schist are very common throughout the county. They occur generally in the form of narrow belts or bands in the gneisses, and are frequently well exposed in the cuts of the railroads traversing the county. These two rocks seem to grade into each other; and they are frequently difficult to differentiate without the use of the microscope. They are all more or less laminated or sheared; and they evidently have a common origin. The following is a description of a specimen of the diorite type, taken from a cut on the Georgia Railroad, two miles south of Stone Mountain station:—

Quartz-Diorite. This is a black-and-white-speckled, coarse-grained, slightly schistose rock, forming a zone in the mica-schist several feet in width. The chief mineral constituents of the rock are feldspar, hornblende and quartz, each readily recognized without the use of the lens. Thin sections, when studied under the microscope, show, in addition to the above named minerals, a considerable amount of epidote, which appears to have originated from the breaking down of the feldspar; also, a few shreds of biotite and plates of chlorite. The hornblende occurs in the form of large, irregular, green or brown plates, usually exhibiting beautiful prismatic cleavage. The feldspar is more or less completely broken down, and only occasionally shows distinct continuous twinning striæ. The quartz grains are frequently fractured and show uneven extinction, which is evidently due to the movement of the particles of the rock, since its consolidation. The diorite, as here described, when fresh, possesses all the essentials of a good road material. It is much more durable than either the granites or the gneisses, on account of its superior toughness. The hornblende-schists of DeKalb county, when not too distinctly laminated, are also preferable to the gneisses and granites for road-surfacing.

Trap Rock was located by the writer at only two places in DeKalb county, namely, on the Stone Mountain public road, $2\frac{3}{4}$ miles east of Decatur, and in a cut on the Southern Railway, a few hundred yards south of the trestle crossing South river. The trap at the former locality occurs in the form of two small dikes, apparently not over five or six feet in thickness. The rock occurs in rounded, weathered boulders, scattered about the cultivated fields at this point, indicating an extension of the dike to the southward. The trap, here exposed, is a true olivine-diabase. It is a medium coarse-grained, dark-gray rock, whose weathered surface reveals numerous crystals of plagioclase. Besides this mineral, biotite and secondary hornblende are also easily recognized by the unaided eye. Examination under the microscope, in thin section, reveals, in addition to the above minerals,

the presence of augite, olivine and magnetite. The plagioclase is seen as rather thick, stout, lath-shaped crystals, which are generally quite fresh and distinctly striated. The brown and green hornblendes form narrow margins around the other ferro-magnesian minerals, from which they have been evidently derived. The olivine is very abundant, and is much altered. The altered product appears to consist largely of pale-green amphibole needles or fibers, arranged more or less perpendicular to the surface of the original mineral. The augite appears mostly as large, irregular plates, having distinct cleavage, and frequently having numerous minute inclusions, with their longer axes parallel. The magnetite and biotite occur only in small quantities. The rock, here described, possesses all the qualities of a first-class road-material.

The other exposure of trap rock, spoken of above, is also in the form of a small dike. It is associated with pyroxenites and other ferro-magnesian rocks, which form a belt a mile or more in width at the above named point. This rock differs from the true diabase, in having a granitoid structure and a large quantity of secondary hornblende present; also, a small amount of enstatite and hypersthene. It is a very difficult rock to break; and it would make a durable and valuable material for road-surfacing. A rock similar to the above, and probably a continuation of the same dike, is to be seen on the McDonough road, about a quarter of a mile south of South river. The exposure at this point has a thickness of several feet, and is quite conspicuous in the cut of the road, where the outcropping occurs in the form of rounded boulders.

ROCKDALE COUNTY

Area, 126 square miles; approximate road-mileage, 222; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained mainly by

statute labor, and are worked, on an average, three days each year.

The County Ordinary, in speaking of the roads of Rockdale county, says: "We work our roads, under the old law, occasionally expending small sums in blasting, making fills, etc. One of the main difficulties in the way of road-construction in our county is due to the way, in which the roads were originally laid out. They frequently extend up and down hills without any regard whatever to grades. Before any improvement of a permanent nature is undertaken, many of the roadways should be re-located." The road materials are granites, gneisses, schists and probably trap. The granites are very abundant in the vicinity of Conyers, where they are quarried for building purposes. They are generally of fine grain, and are fairly well-suited for road-construction. Trap rock is reported, in several localities; but its mode of occurrence and extent have not been investigated.

The county owns about 5,000 feet of public bridges. All of them are made of wood, and are generally in good state of repair.

WALTON COUNTY

Area, 389 square miles; approximate road-mileage, 750; number of miles of graded road, 50; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, \$9,500. The roads are constructed and maintained by convict labor.

Walton county is generally hilly. The soils are mostly clayey, and are well suited for road-building. The streams are numerous. The larger ones are spanned by well constructed wooden bridges, one of which has been recently replaced by an iron bridge, costing \$800. The highways of Walton county are in fair condition. They have been greatly improved under the present system of road-working, which went into effect in August, 1895.

The roads of Walton county are now kept up entirely by convict labor. The number of convicts employed varies from 25 to 30. They are under the direction of a superintendent, who is paid

\$47.50 per month. The cost of working each convict is placed at \$9.44 per month. This estimate includes the cost of guarding, clothing, subsistence account, etc. The guards, three of whom are regularly employed, receive \$20 each per month.

The county levies a special road-tax of $1\frac{1}{2}$ mills on the dollar, of all taxable property. The amount, thus collected last year from this source, was \$4,500, making a total of \$9,500, available for highway improvement.

The road-working outfit belonging to the county consists of two road-machines, several wheeled and drag scrapers, plows, wagons, 19 mules, etc.

The road-building materials are granites, gneisses, schists and trap rock. The first three named varieties of rock are widely distributed, and can be had at almost any point in sufficient quantities for road-building purposes. A large exposure of gneiss may be seen on Mr. W. H. Bush's property, near Winder.

Trap rock (olivine-diabase) was examined at only one locality in the county, namely, near Flat Rock Creek bridge, one mile northwest of Jersey post-office. This is a medium coarse-grained rock. Plagioclase, augite and olivine are easily distinguished. The color is a dark-gray with a slight tinge of brown, due apparently to the presence of olivine together with its alteration product. Thin sections under the microscope show the typical ophitic diabase structure. The plagioclase occurs in rather large lath-shaped crystals, which are often cross-striated, and more or less fissured or broken. Kaolinization appears in many of the crystals. The round grains and irregular masses of olivine, in places, are almost completely altered to serpentine. Magnetite is of common occurrence. It is generally in the form of irregular masses, intimately associated with the olivine. The broad, well striated plates of augite are quite conspicuous under the microscope, and make up a considerable portion of the section. A small amount of chlorite is present. The rock occurs in the form of large boulders, well rounded, and very difficult to break. It is said to be

quite abundant in the vicinity. It has all the essentials of a first-class road-material.

Other exposures of trap rock are reported in the county; but they were not visited.

OCONEE COUNTY

Area, 168 square miles; approximate road-mileage, 150; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

The highways of Oconee county are kept up under the old road law; and, as a general rule, they are not always in good condition. The road-building materials are granites, gneisses and schists. Trap rock is reported to occur near Bell's mill on the Apalachee river, some twelve miles southwest of Watkinsville.

The county owns one iron bridge, which crosses the Apalachee river, on the road from Athens to Madison.

CLARKE COUNTY

Area, 140 square miles; approximate road-mileage, 150; number of miles of graded road, 12; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, \$10,500. The roads are constructed and maintained by hired free and statute labor.

Clarke county is generally hilly, and considerable grading, in places, is necessary in constructing good roads. This county has recently taken considerable interest in the improvement of its highways, and many of the leading thoroughfares are now being put in excellent condition. The county employs both hired free and statute labor. The former is employed, mostly, in grading and doing work of a permanent nature; while the latter does general repair work, and keeps the roads in a passable condition. The County Commissioners have passed a rule, requiring all persons in the county, subject to road-duty, to work eight days on the public

roads, or to pay a commutation-tax of \$2.00. The amount collected from this source last year¹ was \$900.

The Superintendent of Public Roads, in speaking of the method of road-working in Clarke county, says: "The Commissioners have decided to employ the misdemeanor convicts next year. Our experience teaches us, that the commutation-tax does not obviate the difficulty of getting our roads repaired properly. The law of 1891 would operate to a better advantage. We should levy a tax, giving no alternative of working. It is well nigh impossible to have farm-hands do good work, because they are untrained; and the overseers, as a rule, allow them to kill time."

The county employs regularly, on its highways, at present, one superintendent, one overseer and several laborers. The superintendent is paid a salary of \$1,200 per year, and the overseer, \$480; while the laborers receive 75 cents per day.

The road-working outfit consists of a road-machine, wheeled and drag scrapers, wagons, ten mules, etc., costing originally about \$700. The superintendent says, that the road-machine is operated by six mules and three men, and that it does the work of at least 40 men in crowning the roads.

Clarke county has an abundance of granite, gneiss, schist and trap rock, suitable for road material. The trap rock was examined by the writer, at only two places in the county, specimens from which are here described:—

Museum No. 1,592. *Olivine-Diabase*. Locality—W. D. Dean's property, Lexington public road, six miles east of Athens. This is a medium fine-grained, dark-gray diabase, occurring in the form of a dike, several feet in thickness. Microscopically, the rock is seen to be quite homogeneous; and it exhibits a beautiful ophitic structure. The lath-shaped plagioclase crystals are quite fresh and well twinned. They are surrounded by broad typical plates or irregular grains of augite, often showing distinct cleavage. The olivine occurs as rounded grains, and also as well defined crystals, with corroded edges. Magnetite and chlorite are both present. The former is quite plentiful, and is frequently in the form of crystals.

¹ 1899.

Museum No. 1,618. *Olivine-Diabase*. Locality — Mitchell bridge, four miles west of Athens. This rock occurs at the above point, intersecting the public road, in six distinct dikes, varying in thickness from twenty inches to thirty feet. They are almost vertical, cutting the gneiss at a high angle. The strike is northwest and southeast.

The rock from the largest dike is very coarse-grained, and is speckled by large white crystals of plagioclase, which are quite conspicuous on a freshly broken surface. Augite, olivine and magnetite are also easily discernible, megascopically. The plagioclase crystals are frequently a quarter of an inch in length, and often show, even to the unaided eye, evidences of kaolinization. Under the microscope, all the above named minerals, together with a considerable amount of chlorite, are readily made out. The large lath-shaped crystals of plagioclase are often much broken down, and show only an imperfect twinning structure. The augite occurs, as large plates surrounding the plagioclase crystals; also, as irregular grains, which, together with the olivine, chlorite and magnetite, fill up the interstices. Magnetite is rather abundant. It occurs as irregular masses, intimately associated with the rounded grains of olivine and flakes of chlorite.

OGLETHORPE COUNTY

Area, 528 square miles; approximate road-mileage, 350; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, 0; number of days worked by hands each year, 3. The roads are constructed and maintained by statute labor.

The surface of Oglethorpe county is rolling. The soils are mostly clays, frequently mixed with considerable sand, derived from the weathering of the granites. They are well adapted to road-building, because they are easily drained.

The road materials are granites, gneisses and schists. The granites are well exposed in the vicinity of Lexington, where the



A CHATHAM COUNTY MACADAM ROAD, NEAR SAVANNAH, GEORGIA.

stone has been quarried for many years for building and ornamental purposes. It is a dark-colored, fine-grained granite, and is well suited for road-metal. Trap rock is reported to occur in what is known as the Flat-woods in the eastern part of the county; but the locality was not visited by the writer.

WILKES COUNTY

Area, 464 square miles; approximate road-mileage, 400; number of miles of graded road, 100; number of miles of macadamized road, 30; amount of money annually raised for public-road purposes, \$8,500. The roads are constructed and maintained by hired free and convict labor.

The surface of Wilkes county is undulating; and considerable grading is required, in places, to make good road-ways. The soils are mostly sandy, and are easily drained.

The road-building materials are granites, gneisses, schists, diabase and diorite. The last named rock was examined only in two places; and it is thus described:—

Museum No. 1,580. *Porphyritic Diorite.*

Locality—Lincoln road, seven miles northwest of Washington, near Soap creek. This rock is quite abundant in the above named locality; and it has been used to a limited extent for macadamizing purposes. It has a somewhat laminated or slaty structure; and it weathers into small angular blocks, well suited for road material. The color is dark-green, speckled with white spots. The texture is quite compact, none of the individual minerals being recognized by the unaided eye, except the large crystals of feldspar. These are numerous; but they rarely ever measure more than a millimeter in their greatest length.

Microscopically, the rock is seen to consist of hornblende, plagioclase and magnetite. The hornblende consists of numerous needle-like crystals and irregular plates. The latter frequently show parallel cleavage-lines, and are distinctly pleochroic. This mineral constitutes the ground mass of the rock, in which occur

the large, well-twinned, but partly broken down, crystals of plagioclase. Irregular grains of magnetite, together with other minute, elongated dark crystals, probably ilmenite, are pretty evenly distributed throughout the section.

Museum No. 1,585. *Quartz-Diorite*.

Locality — Lindsey Plantation, $3\frac{1}{2}$ miles northeast of Washington. This rock is quite plentiful on the above named property, scattered about over the fields, in the form of rounded boulders. It was not seen at any point, *in situ*. However, the area, over which the boulders extend, makes it quite probable, that it occurs in one or more extensive dikes in the gneisses and schists. The rock has had a limited local use for macadamizing roads, for which it is admirably suited, on account of its toughness. It is distinctly massive, of a dark-gray color, sometimes veined with yellow; and it has such an exceedingly fine, homogeneous texture, that none of its different mineral constituents can be satisfactorily determined by the unaided eye.

In thin sections, the following minerals may be made out, microscopically: Hornblende, feldspar, quartz, magnetite and epidote, with a few patches of pyrite and chlorite. The hornblende occurs in small greenish crystals, which often show prismatic cleavage and strong pleochroism. All the other minerals, with the exception of magnetite, are granular, and are pretty evenly distributed throughout the rock mass. The hornblende, on the contrary, is almost absent in places. This gives to the polished surface a mottled appearance. The epidote is often seen in large irregular, granular masses. It is very abundant; and when segregated along incipient cracks, it produces the yellow-colored veins, spoken of above.

Museum No. 1,669. *Diabase (Trap)*.

Locality — 2 miles north of Washington. Hand specimens of this rock, collected by Dr. T. L. Watson, Assistant Geologist, have the appearance of serpentine; but microscopic examination shows it to consist largely of lath-shaped crystals of plagioclase and secondary hornblende, having a fibrous or massive structure. The rock is very tough; and it would make a good road-surfacing material.

The gneisses and schists are abundant, and are widely distributed throughout the county.

Much interest has been manifested in Wilkes county, in the last few years, in the betterment of the highways; and, as a consequence, the majority of the roads are now in good condition.

The county levies a tax of two mills on the dollar, for road purposes; also, a commutation-tax of \$2.00. The commuted value of a day's labor is reckoned at 33 $\frac{1}{3}$ cents; or, in other words, all persons subject to road-duty are required to work the public roads six days each year, or pay \$2.00. The road-working outfit consists of two Champion road-machines, several wheeled and drag scrapers, plows, wagons, sixteen mules, etc.

The number of convicts employed by Wilkes county, as shown by the last report of the Prison Commission, is 71. The cost of working these convicts is placed by the Clerk of the Board of County Commissioners at 44 cents each per day; while hired free labor is placed at 75 cents per day. These estimates include all expenses connected with the working of either hired, free or convict labor.

LINCOLN COUNTY

Area, 309 square miles; approximate road-mileage, 175; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute-labor.

Lincoln county lies in the eastern part of the State, on the Savannah river, some 30 miles northwest of Augusta. The surface of the county is hilly, and the cost of constructing good roads with easy grades, is necessarily great. The road materials are those, common to the Crystalline belt. The gneisses and schists are the most abundant and widely distributed rocks. In many places, however, they are so deeply weathered, that they appear only in a fresh state along the streams, or in deep washes.

The metamorphic sandstone, forming Graves Mountain, is interesting from a geological standpoint; but it possesses little value as a road-building material. Trap rock is reported from the county, though its exact location and extent is not given.

The road-hands of Lincoln county are said to work, on an average, only two days each year on the public roads; and, as a consequence, the roads are generally in poor condition.

TALIAFERRO COUNTY

Area, 168 square miles; approximate road-mileage, 150; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

Topographically, Taliaferro county is hilly. The soils are generally clays, having sufficient sand to make them well suited for road-surfacing.

The road materials are granites, gneisses and trap rock. The first two here named are abundant; while the trap rock occurs only in a few localities.

A good exposure of the last named rock may be seen in the railroad cut, about 200 yards east of the depot at Crawfordsville, where it occurs in the form of a dike about two feet wide cutting the schists at a high angle. The rock, here exposed, is a dark-colored, rather fine-grained olivine-diabase, containing a few large crystals of plagioclase and augite. An examination of thin sections of this rock under the microscope shows, that it consists of plagioclase, augite, olivine and magnetite. The plagioclase occurs in the form of long, slender, lath-shaped crystals, which are frequently enveloped by the large irregular plates of augite, thus giving rise to a very distinct ophitic structure. The olivine is very abundant. It is always in the form of rounded grains, and often shows an advanced stage of serpentinization. Magnetite occurs both as crystals and grains.

GREENE COUNTY

Area, 361 square miles; total road-mileage, 250; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, \$7,500. The roads are constructed and maintained chiefly by convict labor.

Greene county has been working its highways by means of convict labor for the past two years. The result of this trial, has, so far, been very satisfactory. The roads during this time have been greatly improved, and the system seems to meet the general approval of all the leading citizens.

The chain-gang as now organized, consists of 15 misdemeanor convicts. They are placed under the management of a superintendent, who receives \$35 per month, for his services. There are also, regularly employed, two overseers acting as guards, who are each paid \$20 per month. The expenses of the chain-gang are met by levying a special road-tax of $1\frac{1}{2}$ mills on the dollar, on all taxable property, and a commutation-tax of \$2.00 upon each individual, subject to road-duty. The money value of a day's labor on the public roads of Greene county has been placed by the Commissioners at 30 cents. This low rate has been made, in order to force all persons, subject to road-duty, to pay a commutation, instead of working on the roads. The result of enforcing this rule, enacted by the Commissioners, brings annually into the county treasury nearly \$5,000, which is expended upon the public roads.

Greene county has a very complete road-working outfit, valued at something over \$3,000. It consists of two road-machines, and wheeled scrapers, plows, wagons, a camping outfit, blacksmith's tools, twelve mules, etc. The road-surfacing materials of Greene county are abundant. They consist of granites, gneisses, hornblende-schist and diorite.

A good exposure of the last named rock is to be seen on the public road, about two miles south of Greensboro. It occurs here

in considerable quantities. Megascopically, this is a rather coarse-grained black-and-yellow-speckled rock, in which hornblende and epidote are quite conspicuous. The former mineral frequently occurs in the form of imperfect crystals, often a sixteenth of an inch or more in diameter ; while the latter is present in irregular masses, filling up, in a great measure, the intervening space between the hornblende crystals, and giving to the rock its yellowish, mottled appearance. Microscopic examination reveals, besides the two above named minerals, a large quantity of plagioclase, much decomposed, considerable quartz, and a few scattering grains of augite and magnetite. The rock is very tough, and is well suited for road-surfacing. Trap rock (diabase) is reported as occurring in several places in the county ; but the localities were not visited.

MORGAN COUNTY

Area, 322 square miles ; approximate road-mileage, 450 ; number of miles of graded road, 40 ; number of miles of macadamized road, 0 ; amount of money annually raised for public-road purposes, \$8,500. The roads are constructed and maintained by hired free labor.

The highways of Morgan county have been kept up, by means of hired free labor, for about seven years. The County Commissioners, in speaking of the method, say : " We are very well pleased with the system, under which we are working. The greatest trouble is, that we have so much more road, than we have money, that we cannot do it justice. We cannot get over the road fast enough."

The road-working force, as now employed, consists of from 20 to 30 laborers, paid 50 cents per day, and two overseers, one receiving a salary of \$50 per month, and the other, \$20. The expense of maintaining the road-working force is met by a special road-tax, of one mill on the dollar, and a commutation-tax of \$2.00, exacted of all persons subject to road-duty. The amount, thus collected, aggregates about \$8,500, of which \$5,800 is collected as

commutation-tax. The value of a day's labor, when commuted, is rated at 25 cents; that is, all persons subject to road-duty are required to work the highways eight days each year, or pay the commutation-tax of \$2.00.

The road-working outfit consists of two road-machines, several road-scrapers, carts, wagons, 20 mules, etc., all in good condition. The work, so far done by hired labor on the public roads of the county, has been confined chiefly to general repair work; but, at the same time, there has been considerable grading done, and, in a few places, there has been a limited amount of macadam put down. It is the intention of the Commissioners, to begin, at an early date, improvements of a more lasting nature—such as the erection of iron bridges, grading down hills, etc.

The road materials are granites, gneisses, schists and diorite. The first three kinds of stone are widely distributed throughout the county; while the last named, the diorite, occurs only in a few localities. A good exposure of the diorite is to be seen at the residence of Mr. J. H. Morgan, a short distance from Buckhead. It is very compact and fine-grained, and is well suited for road-surfacing.

NEWTON COUNTY

Area, 260 square miles; approximate road-mileage, 250; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

The surface of Newton county is generally rolling, and the roads, in places, are often steep.

The rocks, suitable for road material, are abundant. They consist of granite, gneiss and trap (diabase). The last-named rock occurs in considerable quantities, in the vicinity of Covington. In the several railroad-cuts between the depot at Covington and the bridge across Yellow river, there was seen by the writer no less than eight trap dikes. These dikes are usually small, vary-

ing from a few inches to five feet or more in thickness. The largest of these is well exposed in the second railroad-cut west of the depot. In a field near by, may be seen a stone fence constructed of rounded boulders from this dike. Another dike, of small size, crosses the public road, a short distance west of Oxford; and it again outcrops in the worn-out fields just back of Emory college campus. The rock in all these dikes is identical, being a close-grained, dark-colored, olivine-diabase, possessing all the qualities of a first-class road-surfacing material.

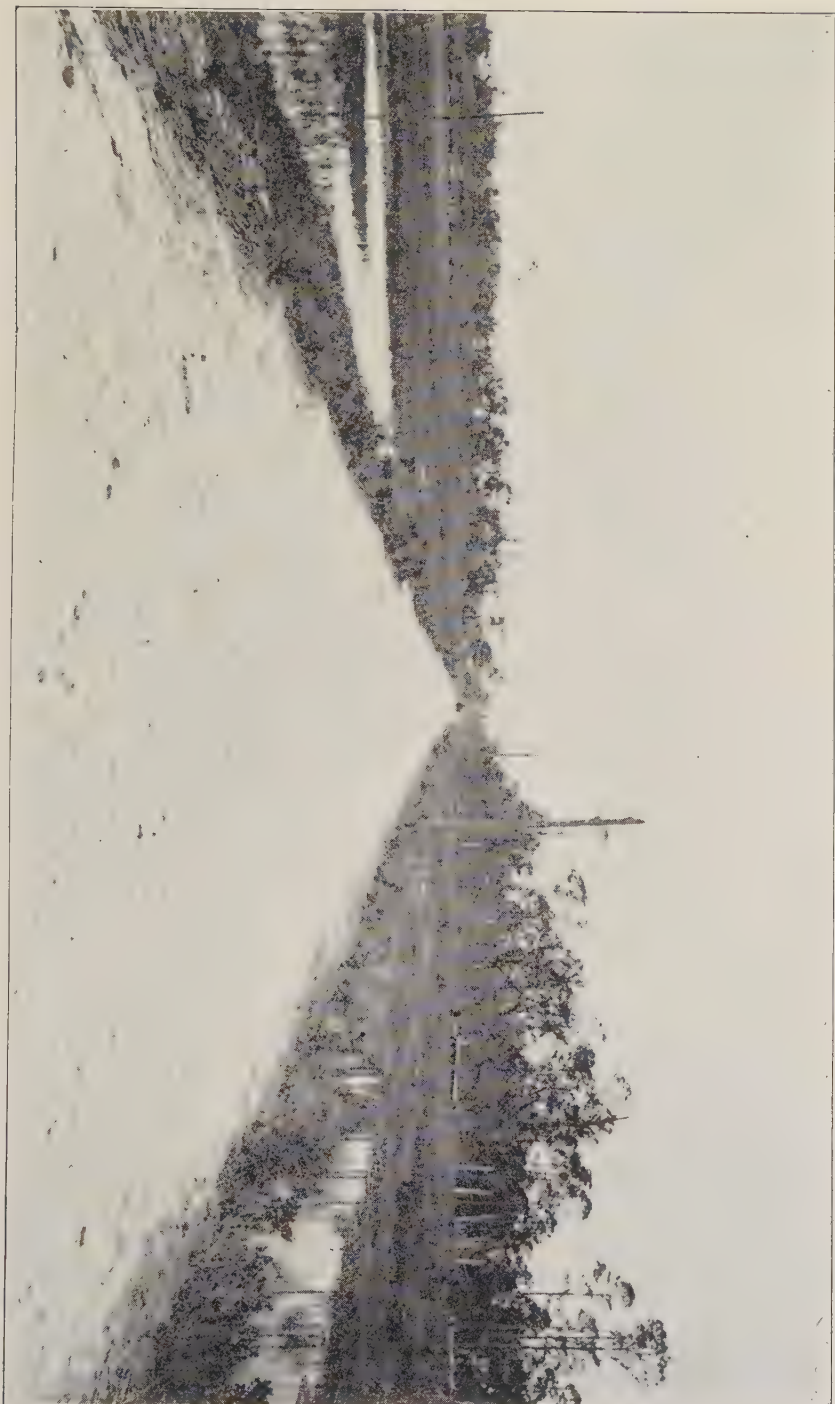
The roads of Newton county were found to be in fair condition, considering the system, under which they are maintained.

HENRY COUNTY

Area, 570 square miles; approximate road-mileage, 450; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

But little interest seems to have been manifested in Henry county, so far, in the betterment of its highways. The roads are kept up entirely by statute labor. The hands work, on an average, five days each year. The roads, as a general rule, are in fair condition, considering the method, under which they are maintained. The Ordinary says, that the present system of road-maintenance is unsatisfactory, but that no immediate change is anticipated.

Henry county has an abundance of gneisses and hornblende-schist, suitable for road-surfacing material. A considerable exposure of granite also occurs in the northeastern part of the county in the vicinity of Stockbridge. The stone is fine-grained, and will make a fair road-metal.



A CHATHAM COUNTY GRAVEL ROAD, NEAR SAVANNAH, GEORGIA.

CLAYTON COUNTY

Area, 135 square miles; approximate road-mileage, 100; number of miles of graded roads, 0; number of miles of macadamized roads, 0; amount of money raised annually for road purposes, 0. The roads are constructed and maintained by statute labor.

Clayton county lies within the Crystalline area; and, as a consequence, it has abundance of granite, gneiss, hornblende-schist, etc., suitable for road-material. Trap rock is also reported, in the southern part of the county; but the exposures were not visited by the writer. Mr. Z. T. Manson, the County Ordinary, in speaking of their present system of road-working, says: "We have never tried it; but I think to work the roads by taxation would produce the most satisfactory results; and I am sure we would have much better roads." But little interest seems to be manifested in this county in improving the present condition of the highways.

FAYETTE COUNTY

Area, 162 square miles; approximate road-mileage, 200; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

Topographically, Fayette county, like all the other counties in the Crystalline area of Georgia, is hilly; and, in many places, the roads have steep grades. At present, they are kept up by statute labor, as above stated; but the system is said to be unsatisfactory, and is soon to be abandoned. The Chairman of the Board of Road Commissioners informed the writer, that a special tax of about 2 mills on the dollar would be raised during this year¹ for public-road purposes, and that it was their intention to begin working the roads by hired labor in the fall. The roads of the county are reported to be in fair condition, considering that they are worked on an average of only six days each year.

¹ 1901.

The material for road-surfacing, consisting of granites, gneisses and schists, are abundant, and are quite generally distributed throughout the county.

Under the present system of road-working in Fayette county, a day's labor is valued at fifty cents.

COWETA COUNTY

Area, 506 square miles ; approximate road-mileage, 600 ; number of miles of graded road, several ; number of miles of macadamized roads, 2 ; amount of money raised annually for public-road purposes, \$5,000. The roads are constructed and maintained by statute and free labor.

There has been considerable interest manifested in Coweta county, within the last year or so, looking towards the betterment of its highways. The county now levies a special tax of $1\frac{1}{4}$ mills on the dollar for road purposes ; and it also exacts, of each male inhabitant subject to road-duty, five days' labor annually, or a commutation tax of \$2.00. The amount thus collected is distributed to the several districts of the county, where it is expended in hiring hands, for keeping up and improving the roadways. Each district has a superintendent, paid \$1.00 per day, who oversees and directs the laborers. The hired laborers receive each 50 cents per day for their services. The county has expended a considerable sum of money in the purchase of a road-working equipment. This equipment consists of a road-machine, several scrapers, plows, wagons etc. The teams for hauling etc. are usually furnished by farmers, who are thus allowed to settle their special road- and commutation-taxes.

Several of the roads of Coweta county were examined by the writer during the summer of 1899 ; and they were found to be in fair condition for common country-roads ; though, in many places, the grades were quite steep. This defect, in some localities, could be easily overcome, by re-locating the roads ; while in others, a considerable amount of grading would be necessary. The macadamiz-

ing, so far attempted in the county, consists of a few short stretches of road, from 50 to 1,500 feet in length, in boggy or marshy places. The material used for this purpose consists mostly of massive white quartz, collected from cultivated fields. In most cases, the stone is not broken to a uniform size, and, as a consequence, the surface is rough and uneven.

Coweta county has an abundance of granite, gneiss, hornblende-schist etc., suitable for road-material, besides a considerable quantity of trap rock. The last named rock occurs in the form of a large dike, traversing the county in a northwest-and-southeast direction. It is well exposed in a cut on the Central Railway, about 4 miles southeast of Newnan, and also on the Atlanta & West Point Railroad, 3 1/2 miles northeast of Newnan. At the former place, it attains a thickness of about 100 feet; while at the latter, it is reduced to less than 10 feet. About half-a-mile south of the point, where the dike crosses the Central road, is another large exposure of trap rock. This exposure is on the public road, and occurs as four parallel dikes. Two of the dikes, which are only a few rods apart, have a thickness, each, of about seventy-five feet. Between these, and running parallel with them, are the two smaller dikes. The trap rock at this place gives rise to a low ridge, the surface of which is strewn with innumerable boulders of all sizes, from a few ounces to many tons in weight. These boulders have been utilized, to a limited extent, in fence-building; but they still exist in such abundance, at many places along the ridge, as to render the cultivation of the soil impracticable. The rock exposed in all the dikes is practically the same, differing only in texture. It is a fine-grained, dark-gray trap (olivine-diabase), quite tough, and admirably suited for road-surfacing. There is an excellent location for opening up a quarry, at the point, where the dike intersects the Central Railway.¹

¹ See Plate IX.

HEARD COUNTY

Area, 290 square miles ; approximate road-mileage, 200 ; number of miles of graded road, 0 ; number of miles of macadamized road, 0 ; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

The surface of Heard county is quite hilly, and some of the public roads are remarkable for their numerous and steep grades. One of the best examples of these poorly constructed roadways extends from Franklin, the county-seat, to Grantville, a distance of about 17 miles. The road runs almost at right-angles to the trend of the ridges and streams. In the original location of the road, grades seem to have been entirely disregarded. Hills are crossed at right-angles, when a more sinuous route, with a slight increase in distance, would have gained the elevation required on an easy grade. Roads of this character should, in all cases, be re-located, before any work of permanent nature is done on them.

The majority of the roads of the county, with the exception of the cross-country roads above spoken of, are in fair condition, and compare favorably with the roads of other counties throughout North Georgia, where the highways are maintained by statute labor. Heard county in the last few years has constructed an excellent iron bridge across the Chattahoochee at Franklin at a cost of \$12,000. This speaks well for the county, and shows, that there is considerable interest in the improvement of its highways.

The road-building materials of Heard county consist of gneisses, hornblende-schist and diorite. The gneisses are the most abundant stones, suitable for road-surfacing, that occur in the county. Good specimens of this variety of stone are to be seen within the corporate limits of Franklin, where it has been used to a limited extent for building purposes. Hornblende-schist is more or less abundant throughout the county. It is especially common in the eastern part of Heard, near the Coweta county-line. The

only exposure of diorite, examined in the county, occurs on the public road at the Cookville High School. It occurs here in a dike several feet in thickness. The dike is said to extend some distance north and south of this point. The thickness of the dike at the Cookville High School is about 150 feet. The rock is a dark green-and-white-speckled massive rock, having a medium-coarse grain, and weathering into rounded boulders. Both the feldspar and the hornblende are readily recognizable, megascopically. Under the microscope, the rock is seen to be made up of plagioclase and hornblende, with a small amount of augite and quartz. The plagioclase is present in the form of more-or-less angular grains, and slightly elongated imperfect crystals. The latter suggest the ophitic structure.

The hornblende occurs in irregular plates, of a pale-green color, frequently marked with distinct cleavage lines. The rock seems to possess all the qualities of a first-class road-metal.

TROUP COUNTY

Area, 493 square miles; approximate road-mileage, 600; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, not ascertained. The roads are constructed and maintained by statute labor.

Topographically, Troup county is hilly; and the highways in places have steep grades. The Chairman of the Board of County Commissioners, in speaking of the highways, says: "We adopted the commutation-tax system three years ago, and are now getting our roads in fine fix. This system will give us excellent roads, in two more years." The amount of commutation-tax collected is said to be about enough to pay the 12 supervisors, who receive \$1.00 each per day for their services, while actually engaged on road-duty. The commutation-tax is \$2.00. Those who refuse to pay this tax are required to work on the public roads four days each year.

The road materials of Troup county are abundant, and are widely distributed. They consist of granite, schists, diorite and diabase. The following is a description of some typical specimens of these different kinds of rocks:—

Museum No. 1,581—*Biotite-Granite*.

Locality—The LaGrange and West Point road, 5 miles southwest of LaGrange.

This is a dark-gray, medium coarse-grained granite, occurring in the form of huge boulders, frequently a rod or more in diameter. Biotite, feldspar and quartz can be readily detected, megascopically. In thin sections these minerals are seen to be quite fresh, and they exhibit their usual well-known characteristics. Both the mica and the feldspar show evidences of crushing, by the bent condition of many of the crystals. Hornblende and calcite occur as accessories. The former is found in the form of irregular crystals, or elongated masses, showing distinct cleavage. The biotite and hornblende generally have a common orientation. However, this is not very noticeable, megascopically.

Museum No. 1,586—*Quartz-Diabase*.

Locality—Campus of the LaGrange Female College, LaGrange, Ga.

This rock occurs abundantly at LaGrange in the vicinity of the LaGrange Female College. It has been used, to a considerable extent, in building retaining-walls and fences about the city. The late Senator Ben Hill's former residence is partly enclosed by a stone wall constructed of this material. It is well exposed in the cuts of the street, on either side of the college grounds, where it occurs in heavy beds interlaminated with the schists. In the college grounds, it is seen on the surface, as large, somewhat rounded boulders, with a slight tendency to schistose structure. This structure, however, is not noticeable in a hand specimen; nor is it revealed, microscopically, by the orientation of the minerals. The rock is of a dark color; has a medium-coarse grain; and weathers into rounded boulders. Megascopically, hornblende, feldspar and quartz are readily discernible. In addition to these minerals, the

microscope reveals augite, epidote, magnetite and pyrite. The hornblende is the common green variety, strangely pleochroic. It occurs in large irregular masses, frequently exhibiting prismatic cleavage. The augite is not so abundant as the hornblende. Its mode of occurrence is quite similar to the latter mineral; but it is readily distinguished by its non-pleochroism and by its angle of extinction. Both plagioclase and orthoclase are found in nearly equal proportions. Each mineral is quite fresh, and generally free from inclusions. They occur in irregular grains. Comparatively little quartz is present. Epidote is found in small rounded grains, pretty evenly distributed through the section.

Museum No. 1,588—*Diorite*.

Locality—Three miles north of West Point, on the road to LaGrange.

The rock occurs here in the form of a dike, fifteen or twenty feet wide. It weathers into rounded boulders, characteristic of the Georgia trap. The rock is massive, of a greenish-speckled color, and very tough. Feldspar, hypersthene and hornblende are easily recognized, megascopically. These minerals all occur in medium-coarse grains, and are quite fresh.

Microscopic examination shows the rock to be holocrystalline, and made up of the minerals, plagioclase, hypersthene, hornblende, augite, epidote and magnetite. The plagioclase occurs as irregular grains and plates, with rather broad laminæ. Inclusions, both in the form of minute crystals and round bodies, are very abundant in the feldspar crystals. Hypersthene is the most abundant of the ferromagnesian minerals. It is strongly pleochroic, and is usually in the form of large irregular crystals, or rounded grains, always surrounded by a margin of green compact hornblende, which seems to be of secondary origin. There are also plates of hornblende, showing well defined cleavage-lines. This is supposed to be an original mineral. Augite is not abundant. It is frequently surrounded by a margin of green hornblende. Like the hypersthene, magnetite and epidote are both present in the form of grains. The latter is often associated with pyrite.

Museum No. 1,590—*Norite*.

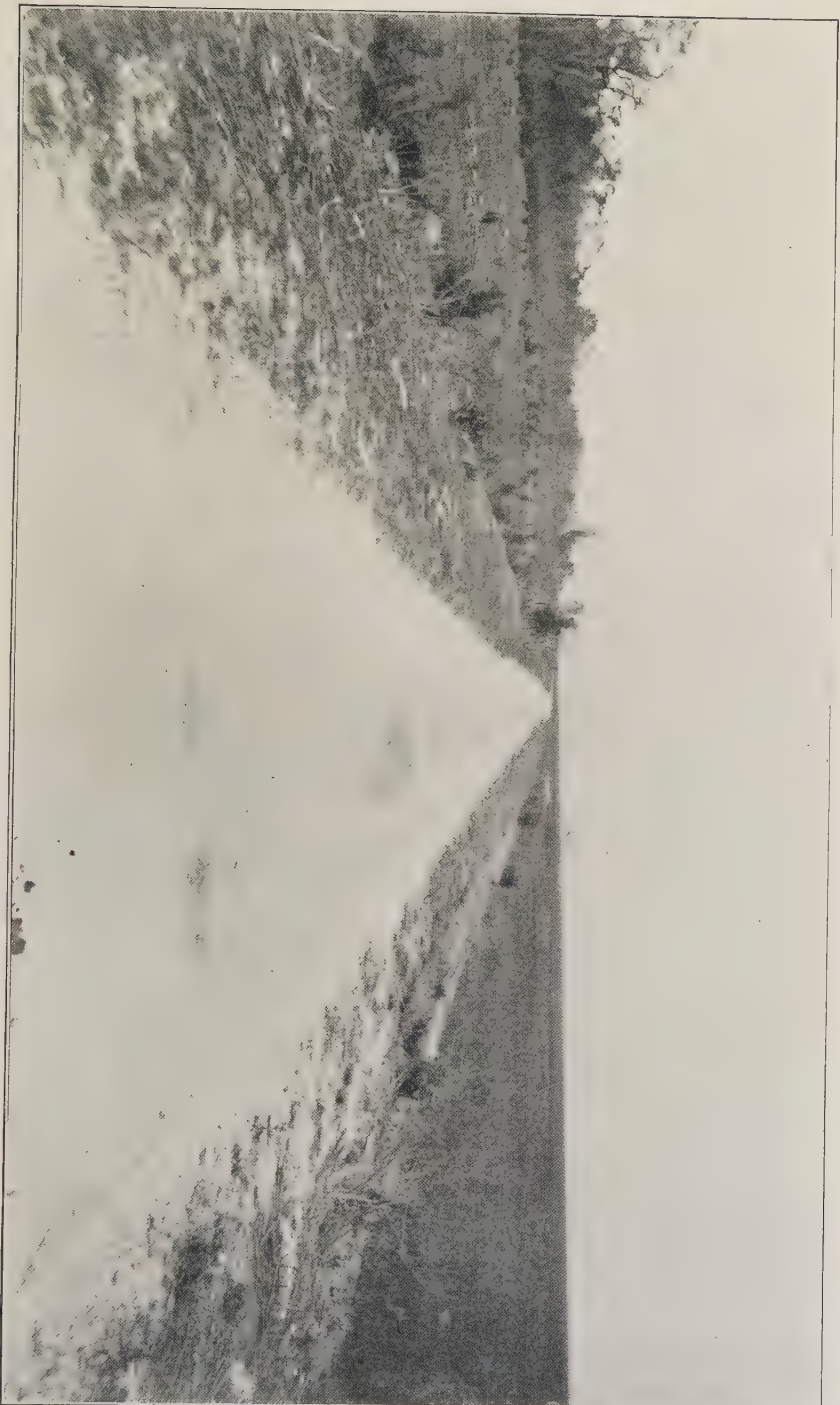
Locality—In considerable abundance on the LaGrange and West Point public road, five miles north of West Point.

This rock weathers into rounded boulders, and has a limited local use, for building fences and retaining-walls. An examination of the boulders, used in the fence on the roadside, showed, that they differ considerably in character. Some are quite massive and compact; while others are more or less laminated. Only one place was found in the vicinity, where these rocks occur *in situ*. This exposure is near the roadside, and is in the form of huge, somewhat rounded boulders. From this place, the specimen for microscopic study was taken. It represents the more massive variety found in the stone fence. The rock is of a dark-green color, with numerous black and white spots, due to large crystals of hornblende and feldspar. Microscopically, the rock is seen to be made up of hypersthene, plagioclase and secondary hornblende, together with a few scattering grains of primary hornblende, magnetite and pyrite. The hypersthene and the secondary hornblende occur in nearly equal proportions. The former occurs in imperfect crystals, distinctly pleochroic, exhibiting more-or-less perfect cleavage-planes. These crystals are frequently surrounded by a narrow band of highly pleochroic, secondary hornblende, which is usually quite compact, and which shows no indication whatever of a fibrous structure.

The plagioclase appears as angular grains and lath-shaped crystals, which, as a rule, are distinctly striated, except where kaolinization has taken place. Inclusions are abundant, both as minute crystals and in what is supposed to be fluid cavities. The primary hornblende, which is not so plentiful as the secondary hornblende, is of a light-green color.

HARRIS COUNTY

Area, 423 square miles; approximate road-mileage, 300; number miles of graded road, 0; number of miles of macadamized



"THE BOULEVARD"—A SHELL ROAD ALONG A SALT MARSH NEAR BRUNSWICK, GEORGIA.

road, 0 ; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

Harris county has made but little progress toward the improvement of its highways. Many of the leading thoroughfares have steep grades, and are often in poor condition for traffic. The Chairman of the Board of County Commissioners says, that the roads are worked, on an average, only about three days each year, and that there seems to be a general lack of interest in road-improvement.

The materials of Harris county, available for road-metal, are granite, gneiss, hornblende-schist, diorite and metamorphic sandstone. The last named rock forms Pine Mountain, which traverses the county from northeast to southwest. In places, this sandstone has been used to limited extent for road-surfacing ; but its friable nature renders it unsuitable for roads with heavy traffic. Probably the best materials, for road-surfacing, to be found in this county, are diorite and hornblende-schist. These rocks, which are often distinguished from each other, only by microscopic examination, are pretty generally distributed throughout the county. Typical specimens of the diorite may be seen on the roadside about half-a-mile east of Hamilton. The rock occurs here in bands several feet wide, interlaminated with the schists and gneisses. It is distinctly schistose, fine-grained, and of dark-gray color. Pyrite, in the form of bright glistening crystals, is the only mineral readily made out, without the use of the lens. A thin section, when examined under the microscope, reveals, as constituents, plagioclase, hornblende, quartz, pyrite, garnet and allanite.

The plagioclase is fresh and well striated. It occurs as irregular grains and imperfect crystals. The hornblende has a pale-green color. It rarely shows distinct cleavage lines. Quartz, one of the most abundant constituents, is present in the form of angular interlocking grains, often containing great numbers of minute inclusions. The other minerals are more or less plentiful, and are quite evenly distributed throughout the section. The rock has a high specific gravity, and is very difficult to break.

The only thing, that detracts from its usefulness as a road-surfacing material, is its schistosity ; otherwise, it seems to be an excellent road-metal.

TALBOT COUNTY

Area, 360 square miles ; approximate road-mileage, 600 ; number of miles of graded road, 0 ; number of miles of macadamized road, 0 ; amount of money annually raised for public-road purposes, not ascertained. The roads are constructed and maintained by statute and hired free labor.

Topographically, Talbot county is hilly in the central and northern portions ; while the southern part is more level. The soils are sandy. In constructing good roads throughout the county, much grading will be required. Especially is this true of the northern portion, in the vicinity of Pine Mountain.

Road-building materials are abundant and of good quality. They consist of granite, gneiss, schists and trap rock. The last named rock occurs as a huge dike traversing the county in a northwest-and-southeast direction.

Good exposures of this rock may be seen within the corporate limits of Talbotton. It is quite abundant at the cemetery, where it occurs in huge rounded boulders ; it is also well exposed in a cut, on the Talbotton Railroad, near by. To the south of Talbotton, the trap rock forms a well defined ridge extending southeast for about four miles. It is last seen on *lots 134 and 135, 16th district*, overlaid by Columbia sands. The dike, in places, seems to attain a great thickness, probably a hundred feet or more. The weathered boulders are often so abundant, as to make the soil practically worthless for cultivation, until they are removed. A specimen of the rock, taken from the cemetery at Talbotton, is thus described :—

It is a dark greenish-gray, fine-grained, holocrystalline, massive rock. The individual minerals are difficult to recognize by the unaided eye. In thin sections, the rock is seen to be made up of plagioclase, augite, olivine and magnetite. These minerals all

occur in the usual form for a typical diabase. Olivine is not so abundant in this rock, as in a majority of the olivine-diabases found in Georgia.

It is an ideal road material in every respect, and should become of general use throughout the county for road-surfacing. The streets of Talbotton should, by all means, be macadamized with this material. Good quarries could be located almost within the corporate limits of the town, and the cost of preparing and placing the stone on the streets would consequently be comparatively small.

The granites, gneisses and schists are widely distributed, and can be had in abundance at many points along all the main thoroughfares.

MERIWETHER COUNTY

Area, 552 square miles; approximate road-mileage, 430; number of miles of graded road, 4; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

Topographically, Meriwether county is undulating, and presents no difficult problems in the matter of road-construction. The hills and ridges are usually low and well-rounded, and can generally be crossed by roads with easy grades. There is one exception, however, to this general rule, namely, the region traversed by Pine Mountain, in the southern part of the county. Here, the surface becomes quite mountainous, and roads with easy grades are difficult to construct, without an outlay of considerable money. Many of the roads in the county, in places, are poorly located. They should be re-surveyed, before any improvement, of a permanent nature, is attempted. Otherwise, the cost of both the construction and the maintenance will necessarily be very great. The roads of the county, at the time of the writer's visit, were found in fair condition, for common country-roads, maintained by statute labor. Probably the best roads in the county are those in the Warm Springs district, where the soils are sandy and easily

drained. In the immediate vicinity of this noted resort, are to be seen some excellent roadways, with graceful curves and low grades, winding along the hill-slopes. These are probably due, in great measure, to individual enterprise. However, they show, in a very striking manner, how roads, even in this mountainous section, can be constructed at small cost, when properly located.

The road-building materials of Meriwether county are granites, gneisses, schists, diorite and trap (diabase).

Typical specimens of the granites of the county may be seen at the Greenville Granite Company's quarry, near the corporate limits of Greenville; also, at the Tigner quarry, located on *lot 68, 7th district*. The stone from these quarries has been used, more or less extensively, for building and ornamental purposes. It has a fine texture, and is well adapted for road-metal.

The gneisses are far more abundant, than the granites. They occur at numerous localities; and, like the granites, they have been used, to a considerable extent, for building purposes. Large exposures of this rock occur at Odessa, and on the H. Warner Hill property, *lot 209, Harris City district*. It is also abundant on Mr. G. A. Barnes's property, adjoining the Hill property, and on *lot 61, 7th district*, owned by Mr. T. B. Tigner. In addition to the common gneisses, here spoken of, there occurs a more-or-less extensive exposure of hornblende-gneiss, on *lot 36, 7th district*. All these gneisses are fine-grained, and fairly well suited for highway-construction.

The most valuable road-materials of the county are the so-called trap rocks (diorite and diabase) here described:—

Museum No. 1,637 — *Diorite*.

Locality — One mile north of White Sulphur Springs, on the road to Greenville.

This is a dark-gray, coarse-grained, massive rock, in which the feldspar and biotite are very conspicuous. Microscopic examination of thin sections shows the rock to possess a granitic structure, and to consist largely of feldspar, and secondary brown hornblende derived apparently from enstatite. Biotite, in the form of irregu-

lar plates, is pretty evenly distributed throughout the section. Magnetite, in considerable quantities, is also present.

Museum No. 1,640 — *Olivine-Diabase*.

Locality — Half-a-mile west of Chalybeate Springs.

This is a fine-grained, dark-gray diabase. The individual minerals are unrecognizable, megascopically. This rock differs from the characteristic Georgia diabase, in the unusually small amount of olivine present. The plagioclase is quite fresh, and the ophitic structure is well developed.

Museum No. 1,651 — *Olivine-Diabase*.

Locality — The Gaston Distillery, four miles north of Greenville.

A dark-gray, homogeneous diabase, in which plagioclase and augite can be recognized megascopically. Examination of thin sections shows the presence of but little olivine; while magnetite in large irregular masses is usually abundant. The augite occurs in plates and in imperfect crystals surrounding and filling the meshes of the felt-like structure, formed of the partly decomposed lath-shaped crystals of plagioclase.

Museum No. 1,658 — *Diabase*.

Locality — Four miles west of Woodbury on the public road leading to Greenville.

This is a typical fine-grained, dark-gray diabase, in which the individual crystalline grains are so minute, that the mineral species cannot be easily determined megascopically. Examination, in thin sections under the microscope, shows a distinct ophitic structure. The plagioclase is quite fresh and well twinned; while the augite occurs in its usual plate-like form. Magnetite is present, in considerable abundance, in irregular masses and imperfect crystals.

All the trap rock (diabase), here described, occurs in the form of a large dike traversing the county, from northwest to southeast. It is the same dike, that extends through Coweta and Talbot counties. In Meriwether county, the dike varies in width, from a few feet to many rods. It seems to attain its greatest thickness in the

vicinity of Gaston's distillery, where it is ridge-forming. The texture of the rock differs but little, from place to place. It is all fine-grained, and is in every respect an ideal road material.

UPSON COUNTY

Area, 325 square miles; approximate road-mileage, 325; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

The surface of Upson county is undulating and broken. Pine mountain traverses the northwestern part of the county. Its highest summit reaches, in places, an elevation of six or eight hundred feet above the valley. To construct first-class roads, with easy grades throughout the county, would require a large outlay of money. Some of the main thoroughfares should be re-located, in places, before any extensive improvement is undertaken. Many of the steep grades could thus be avoided, and the cost of maintaining the roads would be, at the same time, greatly reduced.

The road-building materials are granites, gneisses, schists and metamorphic sandstone. The last-named variety of rock makes up the larger part of Pine Mountain. It is usually friable, and not well suited for road-surfacing. The gneisses are the most widely distributed of the road-building materials. An extensive exposure of this stone may be seen along the falls of Big Potato creek, three miles west of Thomaston. Granites, or granitoid gneisses, are also of common occurrence. Rocks of this character underlie a part, if not all, of Thomaston, and are often encountered in sinking wells in the immediate vicinity. The following is a description of a specimen of this stone taken from a cut on the public road, east of Thomaston :—

Museum No. 1,606—*Biotite-Granite*.

Locality—Road cut, one mile east of Thomaston.

This rock occurs in the form of huge rounded boulders in the red clay, where it has been exposed by the wearing away of the

roadbed. It is quite massive, and has a rather coarse texture and a dark-gray color, slightly tinged with brownish red. The chief mineral constituents can be distinguished megascopically, without much difficulty. Feldspar is the most conspicuous constituent. It occurs in large irregular grains, frequently showing striated surfaces. The other minerals are present in smaller grains, and are therefore not so easily recognized by the unaided eye.

Microscopic examination of thin sections shows the rock to be holocrystalline, and made up of feldspar, quartz, biotite, garnet, augite, epidote and magnetite, with other iron oxides. The feldspar exists, in the form of large grains or irregular crystals, which contain numerous inclusions. Both orthoclase and plagioclase are present. Biotite occurs in elongated plates and shreds, with their longer axes more or less parallel. Associated with the biotite, are to be seen numerous granular masses, of green augite and crystals of garnet. The latter are quite abundant, giving to the rock its brownish-red tint. Epidote is pretty evenly distributed throughout the section in small rounded grains. Quartz, which is quite abundant, also exists in grains; but, in contrast with those of the other minerals, they are remarkably angular and interlocked, which is a structural condition, common to all tough, granular rocks. The rock, here described, has many of the qualities of a first-class road material.

Trap rock was reported, at one or two places in Upson county; but an examination of the rock proved it to be an impure iron ore.

The roads of Upson county, which were examined by the writer during the summer of 1899, were found to be in fair condition; though, in places, the grades were quite steep.

The Chairman of the Board of County Commissioners says, that he has made an effort to get the Grand Jury to make the necessary recommendations, to enable the Commissioners to change the present system of road-working, and use convict labor; but his suggestions have, so far, met with disapproval; and he expresses the opinion, that there is not likely to be a change soon in the present system of road-working.

PIKE COUNTY

Area, 262 square miles ; approximate road-mileage, 175 ; number of miles of graded road, 0 ; number of miles of macadamized road, 0 ; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

Considerable interest was manifested in Pike county toward the betterment of the public roads, as early as 1849. About this time, a stock company was organized, for the purpose of constructing a plank road through the county. This road, though built, was ultimately abandoned, and the interest in highway improvement finally died away. The majority of the roads of the county now, are pretty much in the same condition, as they were, twenty years ago. There are, however, some general exceptions to this general rule. The road, for instance, extending from Zebulon to Jolly station, has had expended upon it, in the last two years, about \$1,500, in grading down one hill.

The County Ordinary reports an average of only about two days' work per year, for each person, subject to road-duty.

Granites, gneisses, schists and metamorphic sandstone occur in the county. The last named variety of rock forms Pine Mountain, in the 7th and 9th districts. The mountain consists of a number of ridges and hills, elevated several hundred feet above the surrounding country. The rock is usually friable, and ill-suited for road-surfacing. Large areas of granite are reported in the northwestern and eastern parts of the county. Hornblende-schist and gneiss are also said to be widely distributed. Almost any of these crystalline rocks will make a fair road material.

SPALDING COUNTY

Area, 166 square miles ; approximate road-mileage, 450 ; number of miles of graded road, many ; number of miles of macadamized road, several ; amount of money annually raised for public-



CULVERT ON BATTLE HILL AVENUE IN FULTON COUNTY, NEAR THE CITY LIMITS OF ATLANTA.

road purposes, \$4,500. The roads are constructed and maintained by convict labor.

Spalding county has done much, in the last few years, toward the betterment of its highways. The present system of working the convicts on the public roads was inaugurated in 1890. The system has met with the general approval of all the leading citizens; and it has produced very gratifying results, in the way of excellent earth-roads. When the system was first introduced, as many as 70 convicts were regularly employed upon the roads. This large force was continued, until all the main thoroughfares were worked over and put in shape. The number then employed was reduced to about 25 men, its present force. This is said to be sufficient to keep all the roads in repair, and also to do considerable work in cutting down the steep grades and macadamizing the wet and boggy places. Owing to the unsystematic method of working, it was found impossible to ascertain the exact number of miles of road graded or macadamized. The main part of the work done, so far, consists in crowning the roads by the use of machines, and opening up the side ditches. With the present force of hands, the Chairman of the Board of County Commissioners says, it is possible to work over all the roads in the county twice each year, and keep them in fair condition. He praises the present system of road-working very highly, and says, there are no defects in it. No one now desires to change to the old system.

The chain-gang, as now organized, is under the direction of a superintendent, whose salary is \$60 per month. There are also three guards, regularly employed at \$30 per month.

The total cost of working convicts in Spalding county is placed at 40 cents per day for each individual. This estimate includes all expenses connected with the chain-gang, embracing superintendent's and guards' salaries, subsistence and clothing account, etc.

For road purposes, the county levies a special road-tax, of one mill on the dollar, on all taxable property. It also exacts of each individual subject to road-duty a commutation-tax of \$1.50. All

persons, who refuse to pay this commutation-tax, are required to work on the public road six days each year. The result of the low price placed upon statute labor, is that nearly all persons pay the commutation-tax. The amount of money thus collected augments the sum available for public-road purposes by nearly one half.

The road-working outfit owned by the county is as follows: Two Austin road-machines, scrapers, wagons, plows, nine mules, a camping outfit, etc. The Chairman of the Board of Road Commissioners speaks in the highest terms of the road-machines. They have unquestionably saved the county many times their value, since their purchase. It would be practically impossible for Spalding county to keep up her highways with 25 convicts, without the use of the road-machines.

The road materials are abundant, and are widely distributed. They consist of granites, gneisses and schists. Extensive exposures of granite, or granitoid gneiss, may be seen at the Turner quarry, one mile north of Griffin. Other exposures, of a similar character occur at different localities in the county. The gneisses proper are more widely distributed, and are better suited for road-metal. Hornblende-schist is also of common occurrence.

BUTTS COUNTY

Area, 204 square miles; approximate road-mileage, 150; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor, and hands work, on an average, five days each year.

The surface of Butts county is undulating, and the soils are usually somewhat sandy. Both the topography and the soils of the county are favorable for road-building.

The main thoroughfares are kept in good condition; though, in places, the grades are steep. Many of the steep hills could be avoided, by re-location of the roads.

The road-building materials are gneisses, schists, diorite and trap.

Typical gneisses of the county may be seen at Indian Springs. They are usually fine-grained, and well suited for road-metal. The schists are very abundant, both the mica and the hornblende varieties. The latter, when not too distinctly laminated, has all the qualities of a good road-surfacing material. Diorite occurs in several localities, a specimen of which is described, as follows:—

Museum No. 1,639—*Quartz-Diorite*.

Locality—Road-side, two miles west of Jackson. A holocrystalline, light-gray, massive rock, in which garnet is the only mineral recognized megascopically. Thin sections, under the microscope, reveal the presence of plagioclase, hornblende, quartz, garnet, epidote and magnetite. The quartz and hornblende are the principal constituents. The former occurs as small angular grains, while the latter is present as irregular, greenish plates, frequently containing inclusions. The plagioclase, which is not very abundant, occurs in small grains with the quartz. It is quite fresh and is well twinned. The crystal faces of the garnets are rarely well formed. They appear mostly as irregular granular masses, similar to the epidote.

Trap rock (diabase) occurs on Mr. H. H. Carmichael's property, six miles west of Jackson. Specimens of this rock were examined by the writer; but its exact location and extent were not investigated. It is a fine-grained, typical olivine-diabase, well suited for road purposes.

MONROE COUNTY

Area, 490 square miles; approximate road-mileage, 325; number of miles of graded road, several; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, not reported. The roads are constructed and maintained by statute, free and convict labor.

Topographically, Monroe county is hilly; and the public roads, in places, have steep grades. The soils are mostly clay; and

when dry they make good roadways. The main thoroughfares are kept up chiefly by convict and hired free labor; while the less important roads are kept in repair by statute labor. At the time of the writer's visit, the chain-gang consisted of only nine convicts. There was also, regularly employed, besides the convicts, a force of six free laborers, each paid 50 cents per day. Both squads of hands were under the management of a superintendent, who received \$25 per month for his services. Two guards were also employed, each receiving the same pay per month as the superintendent.

The county raises a special road-tax, of 1.59 mills on the dollar on all taxable property; it also exacts of each person subject to road-duty, eight days' labor on the public roads, or a commutation-tax of \$3.00. The total amount collected from these sources is not given; but it probably aggregates something like \$6,000.

The road-working outfit owned by the county consists of one Champion road-machine, wheeled and drag scrapers, wagons, 9 mules, etc.

The road materials are granites, gneisses, schists, diorite and trap. The first three varieties of rock, here given, are very abundant, and widely distributed. They can be had in large quantities, at numerous places along all the leading thoroughfares, thus reducing to a minimum the cost of transportation in placing the stone on the road.

The diorite occurs at several localities in the county. One of the best exposures of this rock is to be seen on Mr. C. C. Callaway's property, two miles north of Forsyth. The rock is near a small branch, and is also quite abundant in the adjacent fields, where it forms boulders of various sizes, strewn over several acres. The exposure in the road, and in the branch near by, shows that the rock is usually massive; however, in places it is slightly laminated, and exhibits a somewhat schistose structure.

It is a black-and-white-speckled, medium coarse-grained rock, with a granitoid structure. Feldspar, hornblende and garnets are readily distinguished, without the use of the lens. The first

named mineral is quite conspicuous, owing to its white, pearly lustre, contrasted with the dark-green hornblende. The garnets are very small, but numerous, and are pretty evenly distributed throughout the rock. The hornblende is the most abundant mineral constituent. Augite is also plentiful. The rock is very tough, and well suited for road-surfacing.

A similar rock to the above occurs on the Juliette road, eight miles east of Forsyth. The rock is found here in large quantities. In places, it is so plentiful in the fields, as to seriously interfere with cultivation. To rid the fields of these boulders, they have been piled in heaps; and, in some cases, they have been utilized for making fences. The rock is massive, and of a light-gray color, with a slight greenish tint. It has a uniform and rather fine texture; however, all the principal mineral constituents can be made out, without the use of the lens. Thin sections, when examined under the microscope, disclose the following minerals named in the order of their abundance: Feldspar, hornblende, quartz, epidote and magnetite. The minerals are all comparatively fresh; and the rock is quite tough, and hard to break. It has all the qualities of a good road material.

Trap rock (olivine-diabase) occurs at a number of places in the county. The most extensive exposure of this rock examined by the writer is on the Meek plantation, four miles south of Forsyth. The rock occurs here, in great abundance, forming a hill many feet in height. It is also the most common rock, seen along the public road, for a mile or more south of this point.

The rock is holocrystalline, dark-gray and massive, resembling granite very closely in structure. It is rather coarse-grained. Both feldspar and biotite are easily distinguished by the unaided eye. The latter mineral is pretty evenly distributed throughout the rock, in the form of small plates, which give to the fresh broken surface a glistening appearance.

Under the microscope, the rock is seen to be made up of feldspar, augite, biotite, epidote, olivine and pyrite. Both the plagioclase and microcline feldspars are present; but the former is much

more plentiful than the latter. Augite, the second most abundant mineral named, is in the form of rather large rounded grains whose edges are frequently bordered by a narrow, pale-brown margin of secondary hornblende. Plates and shreds of biotite are unevenly spread throughout the section. This rock differs from the common diabases of Georgia in possessing a granitoid structure; also, in having an unusually large amount of biotite and microcline present.

Another exposure of trap rock (olivine-diabase) occurs on the Middlebrook plantation, seven miles east of Forsyth. This is a greenish-gray, rather coarse-grained diabase. The three chief minerals, namely plagioclase, augite and olivine, can each be distinguished, without the use of the lens. In thin sections, chlorite and magnetite are also seen to be present.

The plagioclase crystals, in places, are partly kaolinized; although the rock, on fresh broken surfaces, looks to be perfectly sound. The rock occurs in a dike, about twenty feet in thickness. It can be traced through the cultivated fields, for some distance, by the rounded boulders strewn about the surface.

Two other dikes, of similar character to the above, were examined by the writer in Monroe county. One of these, which has a thickness of less than three feet, crosses the public road on the way to the Meek plantation, about one mile south of Forsyth; and the other appears on Mr. C. C. Calloway's farm, two miles north of Forsyth.

JASPER COUNTY

Area, 381 square miles; approximate road-mileage, 500; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, \$8,400. The roads are constructed and maintained by convict labor.

The present system of working the public roads of Jasper county went into effect, upon the recommendation of the grand-jury, in 1897. Convict labor is now exclusively used on all the highways,

and is said to be very satisfactory to the tax-payers. The roads have been much improved by the new system, and are in fair condition throughout the county, though, in the winter and early spring, they become quite muddy, in places, a defect to be overcome only by the use of macadam.

The county chain-gang, as now organized, consists of 22 misdemeanor convicts, under the management of a superintendent, who receives a salary of \$45 per month. There is also regularly employed two overseers acting as guards, and two men, who operate the road-machines, each paid \$20 per month. Since the organization of the chain-gang, all the principal roads of the county have been gone over by the road-machines, and their surfaces have been crowned. It is the intention of the Commissioners to begin at an early date improvements of a more permanent nature, such as grading and macadamizing.

The road-working equipment owned by the county consists of 3 road-machines, 1 wheeled scraper and 6 drag scrapers, besides wagons, plows, 18 mules, a camping outfit, etc., all in fair condition.

The rocks suitable for road-surfacing are granites, gneisses, schists and trap, all of which, except the last named, are widely distributed throughout the county. Trap rock also occurs in considerable abundance; but it does not appear to be generally distributed. As far as the writer's personal observation extends, the trap rock seems to be confined to one large dike, traversing the county from north to south. This dike is well exposed about a mile north of Monticello; also, at Hillsboro, and several intervening points. In places, notably in the vicinity of Hillsboro, it forms a well defined ridge, with slopes strewn with innumerable boulders, originating from the breaking down of the dike.

The rock is a medium fine-grained, light-gray, massive, homogeneous olivine-diabase, in which feldspar and a few scattering grains of pyrite may be recognized by the unaided eye. Microscopic examination of the sections shows the rock to contain the usual minerals common to a typical diabase. The plagioclase occurs in rather small lath-shaped crystals, well twinned,

and usually quite fresh. Augite is present, mostly in large brown plates, which enclose the feldspar crystals, and gives rise to a very distinct ophitic structure. Olivine and magnetite are both found in the sections; but neither is abundant.

This rock is an excellent road-surfacing material. It can be easily quarried at several points along the Macon & Northern Railroad. Probably one of the best locations for opening up a quarry, along the line of outcropping, is at Hillsboro, where the railroad intersects the trap dike ridge.

PUTNAM COUNTY

Area, 335 square miles; approximate road-mileage, 250; number of miles of macadamized road, a few; amount of money annually raised for public-road purposes, \$7,000. The roads are constructed and maintained by hired free labor.

Topographically, Putnam county is undulating; and the soils are usually favorable for road building. Many of the highways throughout the county are steep, in places, and need to be relocated, before any work of a permanent nature is undertaken; but otherwise, they are in much better condition, than the average roads throughout the counties of North Georgia.

Much interest has been manifested in this county in the betterment of the highways, since 1892, when the old system of working the roads by statute labor was replaced by hired free labor. This system of highway improvement was kept up, until last year, when it, in turn, was replaced by the convict system, which is now in use, and which seems to give general satisfaction. Under the free labor system, 15 hands were regularly employed. Besides general repair work, this force was able to do considerable grading, in places, as well as to crown many miles of road with the road-machines. The hands, under the system, received 50 cents each per day and subsistence. They were in charge of a general superintendent, or overseer, who directed the work, and who made reports to the Commissioners, from time to time, concerning the



A VIEW OF THE McDONOUGH MACADAMIZED ROAD BETWEEN ATLANTA AND McDONOUGH, GEORGIA.

nature and extent of the work executed. This plan of road-working seemed to have given good results, as is shown by the many miles of well crowned roads throughout the county. The present system of convict labor seems to be another step forward, in the way of highway improvement; and it will probably be only a short time before this county can boast of the best kept earth-roads in this part of the State.

Putnam county has an excellent road-working outfit, consisting of three Champion road-machines, scrapers, wagons, twenty mules, etc., all in fair condition.

The chain-gang, together with the other expenses connected with road improvement, is maintained by a commutation-tax, of \$1.75, and a special road-tax, of 13-4 mills on the dollar, on all taxable property. The total sum, collected from these two sources in 1898, was about \$7,000.

The road materials are abundant and widely distributed. They consist of granite, gneiss, schist, massive quartz and diorite. The granites of this county have more or less extensive use for building and ornamental purposes. They are frequently very fine-grained and well suited for road-surfacing.

The best materials in the county for road-metal, examined by the writer, are the diorites, a specimen of which is here described:—

Museum No. 1,728—*Quartz-Diorite*.

Locality—Electric Light Plant, four miles south of Eatonton.

This is a dark white-and-black-speckled rock, occurring in the form of a huge dike, which crosses Little river at the above point, where it gives rise to the falls, which supply the electric plant with power. The chief mineral constituents of the rock, namely, plagioclase, hornblende and quartz, are readily distinguished, megascopically. The rock is medium coarse-grained, and, in places, shows evidences of shearing. The sample taken was somewhat weathered. Microscopic examination of thin sections shows, that the plagioclase is much broken down, and rarely exhibits distinct cleavage lines. The hornblende is dark-green; it

often shows prismatic cleavage. The quartz occurs in the form of more or less rounded grains, which are often fractured. In addition to these minerals, there is also present, considerable pyrite and epidote, unevenly distributed throughout the section.

This rock has all the qualities of a first-class road-material, with the exception of the decomposed condition of the feldspar, which will probably disappear a short distance beneath the surface.

Other rocks, of a similar nature, occur on Mr. Oscar Reed's property, five miles north of Eatonton; also, on the public road, a quarter of a mile west of Clopton's store, eight miles south of Eatonton. A specimen, Museum No. 1,748, of the last named rock, collected by Professor Yeates, has a somewhat porphyritic structure, due, in great measure, to irregular masses of epidote, which seems to have originated from the breaking down of the feldspar. The hornblende is mostly in the form of elongated masses, or fibres. Large crystals showing prismatic cleavage are also present.

HANCOCK COUNTY

Area, 474 square miles; approximate road-mileage, 400; number of miles of graded road, 200; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, \$4,000. The roads are constructed and maintained by statute and hired free labor.

Topographically, Hancock county is hilly, and the soils, especially in the southern part, are sandy. The northern portion of the county lies within the Crystalline area; and, as a consequence, it is well supplied with granite, gneiss and trap, suitable for road-construction. The granites have been quarried for some years in the vicinity of Sparta, for street paving and for building purposes. These rocks are usually coarse-grained, and are technically known as porphyritic granites. They are rather poorly suited for road macadam; but, owing to their abundance in certain localities, they will probably become of importance in the vicinity of the quarries for road-surfacing. Trap rock is reported as occurring

at several places in the northern part of the county ; but at only one place, namely, on the road to Linton, half-a-mile south of Sparta, was this rock examined. The rock here exposed is a typical dark-gray, fine-grained diabase, showing under the microscope a beautiful ophitic structure. The lath-shaped crystals of plagioclase are quite fresh and well twinned. Olivine is present in considerable abundance, and in places is undergoing alteration. Magnetite, mostly as irregular masses, is pretty evenly distributed throughout the section.

Hancock county employs a General Superintendent of Roads and one Assistant Superintendent. The Superintendent is paid \$50 per month, and the Assistant, \$25 per month, while the common laborers receive 50 cents per day. The road-working outfit consists of one road-machine, plows, scrapers, 16 mules, etc. The expense of maintaining the hired force of hands is met by levying a special road-tax, of two mills on the dollar. The hired force at present is chiefly engaged on the main thoroughfares, crowning them with the road-machine, and otherwise putting them in good condition for traffic. After these principal roads are put in good condition, it is the intention of the Superintendent to go over the less important roadways. Besides the hired labor, statute labor is also pretty generally employed throughout the county, working the full number of days, as required by law.

WARREN COUNTY

Area, 264 square miles ; approximate road-mileage, 400 ; number of miles of graded road, 0 ; number of miles of macadamized road, 0 ; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

Topographically, Warren county is more or less rolling. The soils in the southern part are sandy, and easily drained ; while, in the northern part, they are made up largely of clays, which make good road-surfaces, as long as they are kept properly drained.

Rock suitable for road material is confined chiefly to the north-

western part of the county. It consists mainly of granites and gneisses; although trap rock is said to occur, in considerable quantities, in some places.

The Chairman of the Board of County Commissioners says, that the roads are worked under the old law, but that the system is unsatisfactory. It is thought, that a special road-tax will soon be levied, and the roads will be worked, either by convict or by hired free labor.

The roads are now worked, on an average only about four days each year. They are frequently in poor condition.

MCDUFFIE COUNTY

Area, 235 square miles; approximate road-mileage, 300; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, \$3,500. The roads are constructed and maintained by statute and convict labor.

McDuffie county, in its northern part, is rolling, and the soils are mostly clayey; while, in the southern part, the surface become more level, and the soils are sandy.

The road materials are granites, gneisses, schists etc., confined chiefly to the northern part of the county. There are also, to be found in places, deposits of gravel, suitable for road-surfacing. The chain-gang is kept up, by a special tax of 13-4 mills on the dollar, and a commutation-tax. The former amounts to about \$1,500 per year, and the latter, to about \$2,000. The money value of a day's labor in McDuffie county, when commuted, is rated at 40 cents; and the average number of days, worked upon the road during the year, for each person subject to road-duty, is estimated at five days.

The road-working equipment consists of one new Western road-machine and seven mules. The Chairman of the Board of County Commissioners, in speaking of this machine, says:—"This machine with six mules and two men does the work of at least fifty hands." The present system of working the roads in McDuffie

county is reported to give satisfaction, and the roads are being gradually improved.

COLUMBIA COUNTY

Area, 333 square miles ; approximate road-mileage, 350 ; number of miles of graded road, 0 ; number of miles of macadamized road, 0 ; amount of money annually raised for public-road purposes, \$1,500 ; number of days worked by road-hands each year, 5. The roads are constructed and maintained by statute labor.

Columbia county is situated in the eastern part of the State, immediately north of Richmond county. Its surface is broken, and the soils, especially in the southern part, are sandy. The Chairman of the Board of County Commissioners in this county says : "Our present system is for each male person subject to road-duty, to work five days during the year at such times as he may be called upon, or pay a commutation-tax of 50 cents for every day's work required." The overseers are paid each \$1.00 per day, for every day actually employed on road-duty. The county assesses a special road-tax of two mills on the dollar, of all taxable property. The road-building materials are granite, gneiss, hornblende-schist and massive quartz. Trap rock is also reported to occur in the vicinity of Harlem.

RICHMOND COUNTY

Area, 329 square miles ; approximate road-mileage, 250 ; number of miles of graded road, 250 ; number of miles of sandy road surfaced with clay, 140 ; number of miles of gravel road, 75 ; amount of money annually raised for the maintenance of the chain-gang and the public roads, \$24,000. The roads are constructed and maintained by convict labor.

The citizens of Richmond county have always taken an active interest, in the improvement of their highways. White, in his *Statistics of Georgia*, published in 1849, says, that the bridges and roads at that time were kept in fine condition.

The roads of this county were maintained, until 1879, by means of statute labor, when the present system of road improvement was inaugurated. Judge W. F. Eve, in discussing the road problem of Georgia, before the National Road Parliament, held in the city of Atlanta in 1895, had the following to say, in regard to the method of road improvement, adopted in Richmond county : —¹

"A few years since, the county organized, and placed in charge of her road department a road engineer ; organized her misdemeanor convicts into a road force ; and has made very satisfactory progress. The class of work done in my county was, first, an effort to reduce the grade and to give the roads proper drainage. Then we did a very considerable amount of gravel work. We have a great many miles of gravel road. Our sand beds, which were very extensive, have been hardened by the use of clay. We shape up a bed, and then put from 8 to 10 inches of clay, rolling it ; and then, placing upon it from one to three inches of sand ; and, when the wet season comes, the sand is ground into the surface. Then we shape it up, and give it a crown, and we get it so, it becomes impervious to water—it sheds the water. This road is cheaply made, and a good one to travel over ; and is much more durable than one would think. Then, too, it comes within the reach of our people."

The gravel roads of Richmond county are constructed of gravel obtained from South Carolina, some seventeen miles southeast of Augusta on the Port Royal & Augusta Railroad. This material consists of water-worn quartz pebbles cemented together by iron oxide and sandy clays. It possesses all the essentials of a first-class road material, and its cheapness (65 cents per ton on board of cars at Augusta) insures its general usage, on the highways of Richmond county. The cost of constructing roads of this material, 20 feet wide, has been estimated by Judge Eve at \$1,600 per mile. This seems to be an unusually low estimate, when the excellent quality and durability of these roads are taken into consideration. The chain-gang, as now employed by Richmond county, consists of 75 misdemeanor convicts, each of whom is said to cost the county

¹ Road Bulletin No. 19, U. S. Department of Agriculture, Office of Road Inquiry, p. 16.

30 cents per day. This estimate includes board and clothing of the convicts, and the payment of the following employees, together with all other expenses connected with the chain-gang : —

1 Superintendent, salary per month.....	\$83.33 $\frac{1}{3}$
1 Night watchman, " " ".....	45.66 $\frac{2}{3}$
8 Guards, each.....	30.00

Judge Eve says of the convicts : "We find them the most satisfactory labor for the roads, and the very best disposition to make of the convicts."

Richmond county owns the following road-working outfit : Road-machines, wheeled and drag scrapers, a road roller, carts, wagons, 25 mules, a camping outfit, etc. The road-machines are much used ; and they are said to do excellent work, in crowning and grading the road.

The rocks suitable for road-building material are confined mostly to the northern portion of the county, which is underlaid by the gneisses and other crystalline rocks. In this county, only one exposure of rock, well suited for road-surfacing material, was examined by the writer. This rock is described as follows : —

Museum No. 1,657 — *Gneiss*.

Locality — Quarry near the head of the canal, 7 miles north of Augusta.

This rock has been used quite extensively for the last few years in the city of Augusta, for macadamizing purposes. It is exposed in a bluff, many feet in height near the canal, where a large quarry has been opened up. The rock is very much fissured and jointed, which reduces the expenses of quarrying to the minimum ; but which does not materially injure the value of the stone for the purpose, for which it is used.

Megascopically, this is a very compact, fine-grained, light-gray rock, which has, in places, a decided schistose-structure. Quartz, feldspar and pyrite are the only minerals, distinguishable by the unaided eye. Thin sections, microscopically examined, reveal, besides the above named minerals, epidote, which is pretty evenly distributed throughout the section. The quartz, which forms a

great part of the rock, occurs in small irregular grains, often exhibiting uneven extinction. The feldspar also occurs as irregular grains; but they are generally much larger than the quartz grains. They are neither abundant, nor are they distinctly striated. The City Engineer of Augusta speaks in high terms of this stone as a street-surfacing material.

Besides the above named rock, a few small gravel-beds occur in the vicinity of Augusta, which have a limited local use for road-surfacing. As a general rule, these gravel deposits are mixed with a coarse sand, and are lacking in binding quality.

BURKE COUNTY

Area, 1,080 square miles ; approximate road-mileage, 600 ; number of miles of graded road, 300 ; number of miles of macadamized road, 0 ; amount of money annually expended on public roads, \$9,000. The roads are constructed and maintained by statute, hired and convict labor.

Burke county employs on its public roads an average of 35 convicts and about 20 hired laborers. The latter each receive 50 cents per day, and are under the direction of five overseers, who are each paid \$1.50 per day. These overseers also have charge of the statute labor of the county. The chain-gang is under the immediate direction of four overseers, or guards, three of whom are paid \$20 each per month, and one, \$40 per month. Burke county raises no special road-tax ; but it appropriates, annually, from the general county-fund, \$2,000 for road purposes. This sum is increased by about \$7,000, which is collected as commutation-taxes. The rated money value of a day's labor has been placed by the County Commissioners at 40 cents.

The equipage for road-working, of Burke county, consists of one road-machine, five drag scrapers, plows, wagons, four mules, etc. Mr. J. P. Palmer, Superintendent of County Roads, reports no rock suitable for road-construction, found within the county.



A PORTABLE ROCK-CRUSHING PLANT ON THE PEACHTREE ROAD, NEAR ATLANTA—A PART OF THE ROAD EQUIPMENT OF FULTON COUNTY.

JEFFERSON COUNTY

Area, 640 square miles ; approximate road-mileage, 700 ; number of miles of graded road, 100 ; amount of money annually raised for public-road purposes, \$2,000. The roads are constructed and maintained by convict and statute labor.

The highways of Jefferson county are kept up, at present, chiefly by convict labor. There is also a limited amount of statute labor employed. All persons, subject to road-duty, are required to pay a commutation-tax of \$1.60, or to work upon the public roads six days each year. The latter alternative is sometimes chosen ; and, as a result, there is more or less statute labor utilized upon the highways. Such labor is said to be almost worthless. The Chairman of the Board of County Commissioners, in speaking of the present method of road-working, says : "The system was adopted under much opposition ; and it still has its enemies ; nevertheless, the roads have been greatly improved, and the system is gradually growing in favor. The roads are now, for the first time, being worked in a systematic manner, and, in a short time, under the present management, all the main thoroughfares will be placed in good condition to the county-line."

The chain-gang, as now organized, consists of about 40 convicts. It varies in numbers from 10 to 50, the average being probably about 20. A superintendent and two guards are regularly employed ; but their salaries were not stated in the report of the Chairman of the Board of County Commissioners. The county owns the following road-working equipment : One Champion road-machine, two wheeled scrapers, two drag scrapers, and plows, wagons, eight mules, etc.

No rock, suitable for road material, is reported from Jefferson county. Clay is generally used for surfacing on sandy roads. The chain-gang has been employed, so far, mainly in crowning and widening the roads.

GLASCOCK COUNTY

Area, 90 square miles ; total road-mileage, 100 ; number of miles of graded road, 0 ; number of miles of macadamized road, 0 ; amount of money annually raised for public-road purposes, \$2,000. The roads are constructed and maintained by hired free labor.

Glascok county is the smallest county in the State. It lies wholly within the Tertiary area ; and, as a consequence, its surface is level and sandy. Good roads can be constructed in the county, with comparatively little or no grading. Heavy beds of sand constitute one of the chief obstacles to be overcome, in making hardened ways.

Rock suitable for road-surfacing is almost entirely absent. A ferruginous rock, probably an impure iron ore, suitable for road-surfacing, is said to occur in some localities. Its extent and the exact localities were not given, in the report from that county.

The highways of Glascok county are at present kept up by means of hired free labor. This method of road-working went into effect the first of January, 1899 ; and, so far, it seems to give general satisfaction. The road-working force, as now employed, consists of 16 laborers and 2 overseers. The latter are paid \$1.20 per day, and the former, 50 cents. The county, as yet, levies no special road-tax ; but it raises all money expended upon the public roadways, by exacting a commutation-tax of all individuals subject to road-duty. The money value of a day's labor, when commuted, is rated at 50 cents. The amount of money, thus raised, is reported to be about \$2,000.

WASHINGTON COUNTY

Area, 688 square miles ; approximate road-mileage, 650 ; number of miles of graded road, 0 ; number of miles of macadamized road, 0 ; amount of money annually raised for public-road purposes, \$10,000. The roads are constructed by statute, hired and convict labor.

There has been much interest manifested in Washington county

recently in good-road improvement. In January, 1898, the new road-law, after much opposition, went into effect; and a special tax, of one mill on the dollar, together with a commutation-tax, was levied for road purposes. The amount of money, collected from these two sources last year, was \$3,500 and \$6,500, respectively; making a total sum, of \$10,000, available for road-improvement. The roads of the county, as now improved, are under the management of seven superintendents and twenty-one overseers, appointed by the Commissioners. The superintendents are paid \$2.00, and the overseers, \$1.00 each per day for their services, while actually engaged on road-duty. In addition to hired and statute labor, the county employs a chain-gang of about 15 convicts. This force is engaged mainly, in rounding up the roads with the road-machines, and doing general repair work.

The county owns the following road-working outfit: 3 road-machines, 126 wheel-barrows, 252 picks, 252 shovels, 12 spades, 36 axes, 126 hoes, 126 mattocks, wagons, 15 mules, etc.

Local beds of fossiliferous limestone, suitable for road-material, are known to occur in the county; but their extent has not been investigated.

BALDWIN COUNTY

Area, 240 square miles; approximate road-mileage, 350; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money raised annually for road purposes, \$6,000. The roads are constructed and maintained by convict labor.

Baldwin county has been working convicts on its public roads for eighteen months. Mr. Daniel B. Sanford, Chairman of the Board of County Commissioners, in speaking of the system, says: "I am satisfied, after 18 months' trial, that to work convicts or paid labor with proper machinery, is the only system, by which respectable public roads can ever be had in Georgia. It is expensive, to organize and operate in the beginning; but, the longer it

is operated, the less the expense will be. 'The old system of working the public roads was, and is still, a farce.'

The road employees of Baldwin county consist of one superintendent, at \$75 per month; one overseer, four guards, and two machine men, each at \$30 per month; and two drivers and one cook, at \$20 per month. The average number of convicts employed is fifteen. Each convict costs the county about \$4.00 per month. The road equipment consists of twenty mules, two Champion road-machines, wagons, scrapers, etc. The county assesses a special road-tax, of two mills on the dollar, and a commutation-tax, of \$2.50 on each individual subject to road-duty. The money value of a day's labor is rated at 30 1-4 cents, and, as a consequence, all persons, assessed, pay the \$2.50 per annum, rather than work out their assessment. From this source, more than one half of the money expended on the public roads is obtained. Baldwin county has three excellent iron bridges, valued at \$20,000.

The road materials of the county consist of granite, gneiss, schist, gravel and trap rock. The first three named varieties of rock are abundant in the northern and central parts of the county; while the gravel occurs in the Cretaceous deposits, which cover much of the southern portion of the county. The only trap-rock examined occurs in a cut on the Georgia Railroad near Fishing creek, one mile north of Brown station. The dike at this point has a thickness of about 75 feet, and consists of a medium fine-grained, homogeneous, dark-gray trap rock (*olivine-diabase*). The margin of the dike has a much finer grain than the center, which is evidently due to a difference in the rate of cooling. In the public road, near by, and also in the adjacent woods and fields, may be seen numerous boulders of trap. Some of these specimens resemble very closely dark, semi-crystalline limestone in general appearance. However, they are much heavier and more difficult to break.

WILKINSON COUNTY

Area, 417 square miles; approximate road-mileage, 700; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, not ascertained. The roads are constructed and maintained by statute labor.

The surface of Wilkinson county is undulating, and the soils are generally sandy. The roads are kept up mainly by statute labor, each person subject to road-duty being required to work eight days each year. A tax of about one third of 1 per cent. is said to be collected for road purposes; but the total amount collected was not ascertained. The county owns one road-machine, which was used for a while; but, owing to the lack of money to operate it, the machine was laid aside, although it is reported to have done good work.

The only rock reported from Wilkinson county, suitable for road-surfacing, is limestone. A considerable exposure of this stone, formerly used in the construction of chimneys, is said to occur near Irwinton. It is a soft, rotten stone, when first quarried; but, after exposure to the atmosphere, it becomes quite hard.

TWIGGS COUNTY

Area, 376 square miles; approximate road-mileage, 350; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, 0. The roads are kept up by statute labor.

The northern part of Twiggs county is rolling; while the southern part is comparatively level. The soils are mostly of a clayey nature, except in the southern portion, where, at some places, they are quite sandy. The roads, which are worked on an average of about 9 days each year, are said to be in fair condition. The present system of road-maintenance is reported by the

Ordinary to give general satisfaction; and no change in the method of road-working is contemplated.

Limestone and flint, suitable for road-surfacing, occur at a few points in the southern part of the county.

JONES COUNTY

Area, 386 square miles; approximate road-mileage, 350; number of miles of graded road, several; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, \$6,000. The roads are constructed and maintained by convict labor.

The highways of Jones county were kept up by statute labor, until January, 1898, when hired free labor was introduced. This in turn was replaced, in a short time, by convict labor, which is still in use. The chain-gang, as now organized, consists of 20 convicts, under the management of a superintendent and two overseers. The latter act also as guards. Each of these employees receives a salary of \$25 per month. The Chairman of the Board of County Commissioners, in speaking of the defects of the present system, says: "One of our mistakes is, that we are using too cheap men for our superintendents and overseers." This statement is unquestionably true, as it hardly seems probable, that a competent superintendent could be had at such a meager salary.

The road-working outfit of Jones county consists of 2 road-machines, 3 wheeled scrapers, 2 drag scrapers, 4 wagons, a camping outfit, 18 mules, and all tools necessary for maintaining first-class earth-roads. The work, so far accomplished by the chain-gang, has been mainly repair work. In addition to this, there has also been considerable work done, in places, in straightening and crowning the roads. At the time of the writer's visit, only about one third of the total road-mileage of the county had been improved by the chain-gang. Some of these roads were examined, and found to be in excellent condition, for common earth-roads.

They were usually well crowned, and had ample side ditches, to carry off all surface-water. Topographically, Jones county is hilly; and much grading will be required, in places, before first-class roads can be constructed.

The soils of the county are favorable for the construction of good roads, except in the southern part, where there is more or less superficial sand. Road-building materials are abundant, and widely distributed throughout the county. Granites, gneisses and schists are all nearly everywhere present. There are also numerous dikes of trap rock, occurring in the county. In going west from Clinton on the Macon public road, the following dikes are to be seen:—

1st,	2 1/2	miles	west	of	Clinton,	thickness,	2 1/2	feet
2d,	5	"	"	"	"	"	4	"
3d,	5 1/2	"	"	"	"	"	5 1/2	"
4th,	6	"	"	"	"	"	50	"

In addition to these, there is a very large dike, many feet in thickness, exposed on the Clinton road, about 200 yards west of Gray's station. This is the continuation of the Jasper County dike, and is one of the largest, as well as the most extensive trap dikes in the State. From Gray's station, it extends southwest, forming a well-defined ridge, running parallel with the Macon and Northern Railroad, some six or seven miles, where it finally disappears beneath the Columbia sands. The most southern exposure of the dike is to be seen in a cut on the Georgia Railroad, only a short distance from Slocum. It here has a thickness of fully 150 feet, and is favorably located for quarrying.¹

The following is a description of a specimen of rock, taken from the dike on the Macon public road, six miles west of Clinton. The rock is a medium coarse-grained, dark-gray olivine-diabase. The center of the dike, from which the specimen was taken, has a muchcoarser texture than the edges, where it comes in contact with the enclosing gneisses and schist. With the exception of

¹ See Plate XIX.

plagioclase, none of the individual minerals are recognizable by the unaided eye.

Microscopic examination reveals the presence of plagioclase, augite, olivine and magnetite, all having the usual form and structure, common in typical diabases. The specimens from the other dikes are very similar to the above, and need no description.

BIBB COUNTY

Area, 235 square miles; approximate road-mileage, 400; number of miles of graded road, 150; number of miles of macadamized road, 0; amount of money raised annually for road purposes, \$19,000. The roads are constructed and maintained by convict labor.

The highways of Bibb county have been kept up, for several years, by convict labor, and they are now in fair condition for common dirt-roads. The number of convicts employed varies from 75 to 120. These convicts are divided into two camps, or gangs, one of which is regularly employed in repair work, while the other is engaged in grading, surfacing and general road-improvement. Under this system, the squad employed in permanent improvement is enabled to get over the entire road-mileage every 12 or 18 months. No attempt, so far, has been made in Bibb county towards building macadamized roads. The surfacing materials used are gravel and clay. The latter is used on the sandy roads, mostly in the western and southern part of the county. A peculiar-colored, somewhat sandy clay, called "calico clay", which occurs at many places in the county, is said to be well adapted for road-surfacing. It compacts well, and produces but little dust, during the dry season. It is also used sometimes on common clay-roads, when the clay in place is quite sticky. Gravel is pretty general throughout the county; but it frequently has a sandy matrix, and does not readily bind into a solid road-surface. This defect is generally overcome by the addition of clay as a binder. A considerable amount of this gravel has been used on



VIEW OF A MACADAMIZED ROAD IN DEKALB COUNTY, 6 MILES FROM DECATUR, GEORGIA.

the streets of Macon; but it has not always given satisfaction, on account of its imperfect binding quality. Besides gravel, there also occurs in the county an abundance of granite, gneiss, limestone and trap rock, all suitable for road-surfacing. The limestones, which are all probably of Tertiary age, are confined chiefly to the southern portion of the county; while the above-named crystalline rocks occur in the northern portion. There are several exposures of trap-rock along the Southern Railway, a short distance north of Macon. One of the most conspicuous exposures of this rock is to be seen in the railroad cut, only a few hundred yards north of the pumping station of the city water-works. The dike here has a thickness of about sixty feet. It continues for several hundred yards, nearly parallel to and only a short distance from the railroad. In places, it seems to be buried beneath the recent gravel deposits; and its presence is detected only by a few boulders of disintegration, scattered along the hill-slope. Something like a mile north of the above-named point, is another dike, exposed in a cut, on the east side of the railroad. The rock forming this dike is slightly laminated, and has evidently been subjected to some movement, since its consolidation. Still further to the north, probably 300 yards, is another dike, much larger than either of the others. All these dikes dip at a high angle, and have a northeast-and-southwest trend. The rock is a medium fine-grained, dark-gray *olivine-diabase*, containing a considerable amount of magnetite. It is very difficult to break; and it weathers into the characteristic rounded "nigger-head" boulders. Each of these dikes, as well as another one near the eight-mile post, is intersected by the Southern Railway. They are all favorably located for opening up quarries.

Hornblende-schists and gneisses, suitable for road-metal, are of common occurrence in the crystalline rocks north of Macon. Massive quartz rock is also more or less abundant. It could be used to advantage, in road-surfacing.

Bibb county is fairly well supplied with road-machinery etc. It owns 35 head of mules, two road-machines, numerous scrapers,

plows, wagons, etc., having a total valuation of several thousand dollars. The chain-gang is under the general direction of a superintendent, who is paid \$80 per month. There are also regularly employed two overseers, seven guards, two cooks and one wagoner, who are paid salaries varying from \$20 to \$36 per month. The county, in the last few years, has constructed five iron bridges, at a total cost of \$57,000. It is the intention of the Commissioners to increase their working force, in a short time, and to begin macadamizing the roadways, or surfacing them with gravel. The long and severe freezes of last winter ¹ rendered many of the roads of Bibb county almost impassable. This, with other causes, has influenced many of the leading citizens of the county to advocate the issuing of bonds for road-improvement.

HOUSTON COUNTY

Area, 570 square miles; approximate road-mileage, 250; number of miles of graded road, 50; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, about \$6,000. The roads are constructed and maintained by statute and convict labor.

Houston county is generally level; and the cost of grading the roads is comparatively small. Both statute and convict labor are employed on the highways. All persons subject to road-duty are required to work the road six days each year, or pay a commutation-tax of \$2.00. The amount, thus collected, together with a special road-tax, of two mills on the dollar on all taxable property, makes a sum of about \$6,000, available annually for road-improvement. This sum is expended chiefly in the maintenance of a chain-gang, consisting of forty or fifty convicts.

The chain-gang is under the direction of a superintendent, who receives an annual salary of \$600. There are also regularly employed four guards, at \$20 each per month. The cost of maintaining each convict per month is placed at \$7.00. It is not

¹ 1898-'99.

stated, whether or not this estimate includes the cost of guarding; but presumably, it does not.

The road-working outfit of the county consists of 16 mules, 6 wagons, 1 road-machine, several wheeled scrapers, plows, etc., valued at about \$1,500. The work of the chain-gang, so far, has been confined mostly to general repair work. Some of the main thoroughfares have been crowned, and are now in excellent condition, for earth-roads.

The road-surfacing material of Houston county consists of limestone. It occurs in several localities in the county; but, only at one place, near Tivola on the Georgia Southern & Florida Railroad, has it been quarried for road purposes.

The rock exposed at the above point consists of highly fossiliferous limestone, containing a considerable quantity of sand. It is friable, and is easily crushed to a powder; but, when wet, it readily coheres forming a compact, solid mass, almost equal to Portland cement. Large quantities of this stone have been used on the streets of Macon, where it has given general satisfaction. Its chief merit as a road-surfacing material lies in its high cementing-power. The stone exists in large quantities, and is easily prepared for the road-bed. It is one of the most valuable and one of the cheapest road-surfacing materials, to be found anywhere in South Georgia; and it should be extensively used in Houston and the adjoining counties, for constructing hardened ways.

CRAWFORD COUNTY

Area, 324 square miles; approximate road-mileage, 255; number of miles of graded road, 0; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

In discussing the present system of keeping up the roads in Crawford county, the Chairman of the Board of County Commissioners, says: "Our roads are worked under the old system. A few days before Court meets, the hands are called out with weed-

ing-hoes and scrapes, and rake in a little straw and dirt, and most of the time get through before dinner. Hence, our roads are in a poor fix. I do not approve this plan; but the above are the facts."

There is abundance of granite and gneiss in the northern part of Crawford county, for road-surfacing. There is also gravel in some places in the southern part of the county, suitable for road-material.

TAYLOR COUNTY

Area, 356 square miles; approximate road-mileage, 300; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, 0. The roads, which are worked annually only about three days, are constructed and maintained by statute labor.

The surface of the northern portion of Taylor county is somewhat hilly, while the southern and central portions are comparatively level. This difference in topography is due in a large measure to the underlying geological formations. The northern part of the county lies within the Crystalline area, while the southern part lies within the Cretaceous area. The surface soils in the latter area are generally sandy and are poorly suited for constructing roads. In many places, as in the vicinity of Butler, the county-seat, and also at other points south of that place, the surface sands are quite thick and render the building of good roads a serious question. The surfacing of these sandy roads with clay greatly improves their condition, as is shown by one of the roadways leading into Butler. However, in many places, this method of road-surfacing is impracticable, as the clay would have to be hauled for a long distance. In the northern part of the county, just the opposite condition from the above exists, that is, clay soils abound, which invariably make unsatisfactory roads during the spring and winter months.

The material for road-surfacing, which consists mainly of granites, gneisses and schists, is confined to the northern part of the county. The material noticed south of the Crystalline area of the

county, suitable for road-surfacing, is gravel, a good exposure of which is to be seen in a cut on the Central Railway, about three miles east of Butler. The gravel, here exposed, forms a bed several feet in thickness, and appears to be of good quality for road-surfacing. In the southern part of the county, sandstone and limestone are reported to be found in a few localities; but neither stone probably exists in sufficient quantities, to be of much importance.

The County Ordinary, in speaking of the public roads of Taylor county, says: "The present system of road-working is unsatisfactory, and it is the intention of the County Commissioners during the present year to adopt a new road-law, and work the roads hereafter by taxation."

MACON COUNTY

Area, 288 square miles; approximate road-mileage, 400; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

Macon county is usually level, and the soils are sandy. The road-building materials consist of limestones, which occur in a few localities. Small exposures of these rocks are to be seen within the corporate limits of Montezuma. They are usually fossiliferous and soft; but occasionally, they become compact and hard. Gravel also occurs in places in the northern part of the county, though the beds are of limited extent. Clays suitable for surfacing sandy roads are pretty generally distributed throughout the county.

The roads of Macon county are worked, on an average, only about three days each year.

SCHLEY COUNTY

Area, 163 square miles; approximate road-mileage, 150; number of miles of graded road, 0; number of miles of macadamized

road, 0; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

Topographically, Schley county is level, and the soils are sandy. The roads are worked under the old law. Sandy roads are improved by surfacing with clay, which is found widely distributed over the county. Limestone rocks occur in some localities; but, so far, they have not been used for road purposes. The county owns no road machinery; and, apparently, but little interest has been taken in the improvement of its highways.

MARION COUNTY

Area, 330 square miles; approximate road-mileage, 150; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

Topographically, Marion county is generally level, and the soils, sandy. The Chairman of the Board of County Commissioners, in speaking of the roads of Marion county, says: "Really we have no system of road-maintenance. The old statute system, by free labor and overseers, is the system, by which we pretend to do work. This is a make-shift at best, and, when poorly enforced, is almost a failure. Our county in this particular, is a half-century behind the times. Commissioners of Roads and Revenues have been recently appointed; and we would attempt reform; but we are handicapped by a heavy indebtedness on the county, imposed by the former management."

The roads are worked, on an average, about five days each year, which is sufficient to keep them in passable condition. Owing to the levelness of the surface, but little grading is required in constructing first-class roads.

The road materials are limestone and gravel, neither of which is abundant, or widely distributed. Clays, for surfacing sandy roads, are plentiful, and nearly everywhere present.

MUSCOGEE COUNTY

Area, 244 square miles ; approximate road-mileage, 200 ; number of miles of graded road, several ; amount of money annually expended upon the highways, not reported. The roads are constructed and maintained by convict and statute labor.

The northern portion of Muscogee county is generally hilly ; while the southern portion is level and sandy. Owing to these topographic differences, the northern and the southern parts of the county present different problems, in the way of road-construction. In the northern part of the county, one of the main questions, to be considered in road-building, is the cost of grading. This item of expense, in many places in the southern part of the county, is frequently reduced almost to nothing ; however, the cost of removing, or covering heavy beds of sand with surfacing material, is often equally expensive. The road-surfacing materials of the southern portion of the county are gravel and clay. The clays are pretty generally distributed ; while the gravel deposits are of limited extent. Good exposures of gravel are to be seen along the Southern Railway, within the corporate limits of Columbus. These gravel deposits are frequently defective in binding quality, on account of the large amount of coarse sand present.

The road materials of the northern part of the county are more varied, and more widely distributed, than those of the southern part. They consist chiefly of gneiss, granite and schist. The most abundant of these is gneiss, much of which is well suited for road-surfacing material. Typical specimens of this variety of rock are to be seen in the bed of the Chattahoochee river, just below the Eagle and Phoenix Mills, at Columbus. The rock here exposed is a dark-colored, banded hornblende-biotite-gneiss. It has been used, to a limited extent, in the city of Columbus for macadam, for which purpose it seems to be fairly well suited. The banded structure of the rock is barely noticeable in a hand specimen ; but it is very pronounced in the natural outcropping

The rock varies considerably in texture. However, it generally has a medium-fine grain, which renders it quite tough, and difficult to break. Hornblende, biotite, feldspar and quartz are readily made out, by the unaided eye.

Microscopic examination of thin sections shows, that the essential mineral constituents are quite fresh, and are quite equally distributed throughout the rock. Chlorite, epidote and pyrite are also present, but only in small quantities.

Granite, suitable for road material, occurs at Flat Rock, on the Southern Railway, some ten miles north of Columbus. There are also exposures of similar stone on the country road extending from Columbus to Hamilton.

The County Ordinary, in speaking of the condition of Muscogee, says: "We work, on our public highways, a chain-gang of about 30 convicts. The cost of each individual, including feeding, clothing and guarding, is, on an average, approximately \$4.50 per month. We pay our superintendent \$50 per month, and the guards, \$30. Besides the chain-gang, which is worked constantly on the roads, the road-hands are summoned, as occasion requires, working on the average about seven days each year."

The chain-gang is now mostly engaged in draining and crowning the road-ways, and doing general repair work. The county has recently purchased a complete portable Champion rock-crushing plant, at a cost of \$1,500. It is the intention of the road authorities to commence at once macadamizing the leading thoroughfares of this county. The roads, as a general thing, are in good condition for common earth-roads.

CHATTAHOOCHEE COUNTY

Area, 220 square miles; approximate road-mileage, 150; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, 0; number of days worked by road-hands each year, 4 to 6. The roads are constructed and maintained by statute labor.

Chattahoochee county is situated in the southwestern part of

the State, on the Chattahoochee river. Its surface is generally level, and the soil, sandy. As far as is known, no rock suitable for road-surfacing occurs in the county. The Ordinary in speaking of the present system of road-working, says: "It has no merits to commend itself."

As the county is entirely underlaid by the Cretaceous formation, clays suitable for surfacing sandy roads must be more or less abundant and widely distributed.

STEWART COUNTY

Area, 450 square miles; approximate road-mileage, 350; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

The road-hands are said to work on the public roads of Stewart county, from 10 to 15 days each year. The County Ordinary, in speaking of the highways of the county, says: "I think our system a very poor one. I favor using misdemeanor convicts on our roads. Machinery should be used, in working the roads. It would greatly reduce the cost of maintenance." He suggests, that an improvement of the roads would greatly increase the value of real estate throughout the several districts.

The county is usually level, and the soils are sandy. No rock suitable for road-surfacing is reported, though clays, which are well suited for surfacing sandy roads, are quite abundant and widely distributed.

WEBSTER COUNTY

Area, 325 square miles; approximate road-mileage, 175; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

The surface of Webster county, in places, is rolling; but it is generally level, and the soils are sandy. But little grading is re-

quired in the construction of the roads. Sand beds occur in certain localities; but they are not usually extensive.

The road-building material is mostly limestone, which occurs in several places in the county. "Iron rock," probably impure iron ore, is also reported, in some localities, in abundance.

The roads of the county are worked only four days each year; and they are reported to be in poor condition, especially during the rainy season.

SUMTER COUNTY

Area, 515 square miles; approximate road-mileage, 300; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, not ascertained; number of days worked by hands each year, about 8. The roads are constructed and maintained by statute and hired free labor.

Sumter county is located in the southwestern portion of the State. Its surface is generally level, and the soils are often sandy. The highways are reported to be in fair condition. They are kept up by statute labor, supplemented by hired free labor. The hired force consists of about 30 hands, who are employed about six months each year. It is under the management of a general superintendent and one overseer. The former is paid \$50 per month, and the latter, \$25 per month; while the hands each receive 60 cents per day. This force is employed mostly in lessening the grades of the steep hills, and in repairing the bad places in the roads throughout the county. It is maintained principally by a commutation-tax. This tax, which is \$2.50, is exacted of all persons subject to road-duty, who do not work upon the roads the required number of days. The road-working outfit belonging to the county, consists of scrapers, plows, picks, shovels, wagons, 6 mules, etc. The mules are used only about six months each year.

The materials for road-surfacing in Sumter county are limited. Limestone suitable for this purpose is found at a few places in the county; but it is too local in its distribution, to become of general

use. Clays for surfacing sandy roads are more or less plentiful, and are widely distributed throughout the county.

DOOLY COUNTY

Area, 750 square miles ; approximate road-mileage, 1,000 ; number of miles of graded road, 0 ; number of miles of macadamized road, 0 ; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

The public roads of Dooly county are reported by the Ordinary to be in poor condition. They are said to be worked, on an average, only about 5 days each year. A few years ago, an effort was made to raise a special road-tax, and to have the roads worked by hired labor ; but the plan met with considerable opposition, and was finally abandoned. The Ordinary in speaking of the present system of road-working, says, that many of the leading citizens of the county are now convinced, that they can never secure good roads under their present system of working ; and, as a consequence, there is said to be a growing sentiment in favor of working the roads by taxation.

Dooly county is generally level ; though, in some places, there are considerable hills. The expense of grading the roads of the county may therefore be said to be but a small part of the actual cost of building permanent first-class highways. The roads, in some localities, are often sandy ; but, as a general rule, the soils are of a clayey nature ; and, as a result, the roads, during the winter and early spring months, are often in a bad condition for traffic.

The only suitable material in the county for road-metal is limestone, which is found in considerable abundance at a few points north of Vienna.

PULASKI COUNTY

Area, 435 square miles ; approximate road-mileage, 250 ; number of miles of graded road, 0 ; number of miles of macadamized road, 0 ; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

The surface of Pulaski county is rolling in the northern part, and level in the southern part. The soils are usually sandy. The road materials are limestones, which occur only in a few localities, mostly along streams. They are frequently compact, and would make fair material for road-surfacing.

The county owns one iron bridge, valued at \$18,000. Owing to the meager report received from this county, nothing definite is known, concerning the true condition of the roads in Pulaski county.

DODGE COUNTY

Area, 414 square miles ; approximate road-mileage, 250 ; number of miles of graded road, 0 ; number of miles of macadamized road, 0 ; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

Topographically, Dodge county is generally level, and the soils are mostly sandy. The road-surfacing materials of the county are limited to limestones, which frequently occur in considerable beds. They are often quite compact, and well suited for road-metal. In the more sandy districts of the county, where rock is wanting, clays can usually be found beneath the superficial layer of sand for the improvement of the roadways.

The roads of Dodge county are reported to be in fair condition ; though the county owns no road-machinery, the ordinary tools only being used for road-working.

LAURENS COUNTY

Area, 761 square miles ; approximate road-mileage, 450 ; number of miles of graded road, 0 ; number of miles of macadamized road, 0 ; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

The greater part of Laurens county is comparatively level ; and, as a consequence, the cost of road-grading is reduced to a minimum. The roads, in places, are quite sandy ; but there is usually plenty of clay at hand, for surfacing. There are, in several localities, extensive out-croppings of limestones, which are well suited for road-metal. Unfortunately, the limestone is not generally distributed throughout the county ; and in many places, it would have to be hauled long distances, in order to be placed upon all the principal highways.

Laurens county raises no special road-tax ; but, in the last few years, it has constructed an excellent iron bridge, valued at \$16,000.

The roads of the county are kept up entirely by statute labor. The hands are said to work, on an average, only four days each year, on the highways.

JOHNSON COUNTY

Area, 266 square miles ; approximate road-mileage, 250 ; number of miles of graded road, 0 ; number of miles of macadamized road, 0 ; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

Johnson county is generally level, and the soils are sandy. The roads are kept in fair condition by statute labor. The County Ordinary is of the opinion, that the time is near at hand, when the public roads of the county will all be worked by taxation. No rock suitable for road-surfacing is reported. The sandy roads are improved by the use of clay, which is more or less abundant throughout the county. The occurrence of limestone in the

artesian well at Wrightsville would indicate, that this rock outcrops at places in this county.

EMANUEL COUNTY

Area, 1,028 square miles; approximate road-mileage, 1,300; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, \$3,500. The roads are constructed and maintained by hired and statute labor.

The surface of Emanuel county is generally level, and the soils are sandy. No rocks suitable for road-surfacing material are reported from this county. All the roads at present are kept up, either by statute or hired labor. Each person residing in the county and subject to road-duty is required to pay a commutation-tax of \$2.00, or work on the public roads four days each year. The amount of money annually collected from this source aggregates about \$3,000. This amount, together with an additional sum of about \$500, which is raised as a special road-tax, is distributed to the several districts of the county, where it is expended in general road-improvement. All the roads in the county are under the management of a superintendent, appointed by the Commissioners of Roads and Revenues. The superintendent has general charge of all the roads of the county, while each district is under the general management of an overseer. The superintendent receives a salary of \$40 per month for his services.

SCREVEN COUNTY

Area, 786 square miles; approximate road-mileage, 600; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, \$12,270. The roads are constructed and maintained by statute and hired free labor.

The surface of the county is level, and the soils are sandy. Lime-sinks and cypress swamps are occasionally to be seen. But

little or no grading is here required, in the construction of first-class roads. The materials for road-construction are limestone and flint. Neither is abundant nor widely distributed. They are exposed mostly in the vicinity of streams or lime-sinks. The limestones are often soft and highly fossiliferous. Exposures of both the limestone and the flint are to be seen on Brier creek near Mill Haven.

The roads in Screven county are reported to be in fair condition. They are worked, on an average, by the road hands, about eight days each year. The statute labor is at present supplemented by hired free labor.

Superintendents or overseers are appointed in each district to take charge of the roads. Ten of these are now employed in the county. They receive \$1.35 per day for their services, when actually engaged on road-duty.

EFFINGHAM COUNTY

Area, 449 square miles; approximate road-mileage, 250; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

Effingham county is situated in the extreme eastern part of the State, between the Savannah and Ogeechee rivers. This section of the State is low and level, and contains but few, if any, rocks, suitable for road-surfacing. The Chairman of the Board of Road Commissioners of this county says: "Our roads are divided into sections of about five miles. Each section is given to one overseer and an assignment of hands, who work the road, on an average, about two days each year. Persons, desiring to be released from working the public roads of this county, can be relieved, on the payment of \$1.00 for each day's labor required. The total amount, annually collected from this source, does not exceed \$20.00."

BULLOCH COUNTY

Area, 903 square miles; approximate road-mileage, 300; number of miles of graded road, 50; number of miles of macadamized road, 0; amount of money raised annually for public-road purposes, 0. The roads are constructed and maintained by statute and convict labor.

Bulloch county employs 15 convicts on its public roads, besides exacting of each individual, subject to road-duty, an average of two days' labor per year. The Ordinary says, that the roads are not what they should be, but that they are gradually improving under the present system. The county levies no special road-tax; but it maintains its chain-gang by appropriation, made from the general county fund. Each convict is said to cost the county only about \$5.00 per month. This amount evidently does not include the expense of guarding and over-seeing. A superintendent and two guards have charge of the chain-gang. The former is paid \$35, and the latter, \$30 per month each. The county has no road-machinery; but it owns a team of mules, which is used, in moving the tools and the convicts from place to place. But little rock suitable for road-material is to be found in Bulloch county. The roads are usually sandy; and the only material at hand for improving their surface is clay.

TATTNALL COUNTY

Area, 1,123 square miles; approximate road-mileage, not ascertained; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, 0; average number of days worked by road hands each year, 2. The roads are constructed and maintained by statute labor.

Topographically, Tattnall county is quite level; and, as a consequence, the cost of the road-grading is reduced to a minimum. Rock suitable for road-surfacing is reported, at several points west of the Ohoopie river. It is probably limestone.



AT WORK ON THE ROAD BETWEEN DECATUR AND CONYERS, GEORGIA, SHOWING 3 OF THE ROAD-MACHINES OWNED BY DEKALB COUNTY.

WAYNE COUNTY

Area, 721 square miles ; approximate road-mileage, 500 ; number of miles of graded road, 0 ; number of miles of macadamized road, 0 ; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

Topographically, Wayne county is quite level. Sand-hills, covered with a stunted growth of oak, are occasionally met with, in the vicinity of the larger streams. Swamps are also more or less abundant.

As far as known, the county has no hard rock, suitable for road-surfacing. Clays, however, suitable for surfacing sandy roads, are more or less plentiful, and widely distributed. The Chairman of the Board of County Commissioners reports the roads to be in fair condition ; but he adds, that some change is necessary before the roads can be much improved.

APPLING COUNTY

Area, 1,074 square miles ; approximate road-mileage, 400 ; number of miles of graded road, 75 ; number of miles of macadamized road, 0 ; amount of money annually raised for public-road purposes, 0 ; number of days worked by road hands each year, 4. The roads are constructed and maintained by statute labor.

This county, which lies in the southeastern portion of the State, is, like all other counties of the Tertiary area, low and level ; and road-grading, as a consequence, is inexpensive. Rock suitable for road-surfacing is reported to occur in several localities in the northern part of the county, along the Altamaha river. The County Ordinary, in speaking of the present system of road-working, says : “We work our roads under the old law ; it is a poor system.”

MONTGOMERY COUNTY

Area, 763 square miles ; approximate road-mileage, 500 ; number of miles of graded road, 0 ; number of miles of macadamized road, 0 ; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

Montgomery county is level and sandy. The chief difficulty to be overcome, in constructing good roads in the county, is the heavy beds of sand, which frequently occur in the neighborhood of the larger streams. Clays are usually to be had nearby, however, for the surfacing of such roads ; but, in some instances, they would have to be hauled quite a distance. No hard rock of any kind, suitable for road material, is reported from this county. Nevertheless, it unquestionably occurs ; as such rock was penetrated in boring the deep wells at Lyons and McArthur.

TELFAIR COUNTY

Area, 491 square miles ; approximate road-mileage, 200 ; number of miles of graded road, 0 ; number of miles of macadamized road, 0 ; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

The roads are worked, on an average, from five to six days each year, and are reported to be in fair condition. The surface of the county is level, and the soils are sandy. Along the larger streams, are frequently more or less extensive swamps which are a great hindrance in the way of road-construction.

No hard rock suitable for road material is reported from the county. Clays can usually be found, for surfacing sandy roads.

The Chairman of the Board of County Commissioners expresses the opinion, that the system of road-improvement, now in use in Telfair county, is the best, that can be had, under present conditions.

COFFEE COUNTY

Area, 1,145 square miles; approximate road-mileage, 500; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money raised annually for road purposes, 0. The roads are constructed and maintained by statute labor.

There seems to be but little effort put forth in Coffee county for the betterment of its highways. The Chairman of the Board of County Commissioners expresses the opinion, that the system, under which the roads are kept up, is not satisfactory; yet he does not indicate, that there is likely to be any change, soon. The surface of Coffee county is generally low and sandy. No rock, suitable for road-material, is reported from the county.

IRWIN COUNTY

Area, 601 square miles; approximate road-mileage, 300; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

Irwin county is level, and the soils are usually sandy. The only hard rock, reported from the county, is sandstone. It is said to occur only in a few localities, and is limited in quantity. The Chairman of the Board of County Commissioners, in speaking of the roads of Irwin county, says: "We use only statute labor, and our roads are poorly worked. I am satisfied, that we can never have good roads, until they are worked by direct taxation, and the use of the chain-gang."

WILCOX COUNTY

Area, 563 square miles; approximate road-mileage, 250; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, 0; average number of days worked each year on the public

roads by each hand subject to road-duty, 4. The roads are constructed and maintained by statute labor.

Wilcox county is level and the soils are sandy. No hard rocks suitable for road-surfacing, as far as known, occur in the county. Clays for surfacing sandy roads are more or less widely distributed.

WORTH COUNTY

Area, 750 square miles ; approximate road-mileage, 300 ; number of miles of graded road, 0 ; number of miles of macadamized road, 0 ; amount of money annually raised for public-road purposes 0. The roads are constructed and maintained by statute labor.

Topographically, Worth county is level, and the soils are usually sandy. Limestone, sandstone and flint rock are reported to occur in several localities ; but, so far, none of them has been used to any extent for road purposes. The Ordinary says : "Our people do not care to make any change in the present system of road-working ; they think that it is good enough."

The roads of the county are reported to be worked, on an average, about six days each year.

LEE COUNTY

Area, 360 square miles ; approximate road-mileage, 500 ; number of miles of graded road, 25 ; number of miles of macadamized road, 0 ; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

The surface of Lee county is level, and the soils, usually sandy. The road-grading, spoken of above, consists chiefly in crowning the roadbeds, which costs on an average only about \$25 per month. The roads are worked from six to eight days each year ; and they are usually in fair condition for traffic. Limestone suitable for road-surfacing occurs in the county ; but it is not widely distributed. The county owns two steel bridges, which were constructed at a cost of \$1,200 each.

TERRELL COUNTY

Area, 320 square miles; approximate road-mileage, 250; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

Topographically, Terrell county differs but little from Telfair. The County Ordinary says: "Our roads are poorly worked. I think our next Grand Jury will change our system of working the roads by adopting the new law."

Limestone suitable for road material is reported, at several points in the county. Clays are used in improving the surface of sandy roads. They are widely distributed, and can be had on nearly all the leading thoroughfares, with but little expense in hauling.

DOUGHERTY COUNTY

Area, 312 square miles; approximate road-mileage, 250; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, \$3,000. The roads are constructed and maintained by convict labor.

Dougherty county is generally level, and the roads require but little grading. The roadbeds of the western part of the county usually consist of clays, while, in the eastern part, they are sandy. Deep sand beds and low-lands, or swamps, are the main obstacles to be overcome in highway improvement in Dougherty county. The surface of the sandy roads has been greatly improved, in many places, by covering them, to the depth of four or five inches with clay, which is frequently to be had at the roadside, by removing the superficial layer of sand.

Dougherty county works, on an average, about 30 convicts on its highways. The chain-gang is under the direction of a superintendent and one assistant, who receive salaries, respectively, of

\$600 and \$300 per year. There are also three guards, regularly employed at \$20 each per month. The cost of maintaining the chain-gang — that is, the expense of feeding, clothing and medical treatment of each individual — is approximately 20 cents per day. If, to this cost, there be added the expense of conviction, the superintendent's and assistant's salaries, guard-hire, etc., the entire cost to the county of maintaining the chain-gang aggregates about 65 cents per day for each individual.

The equipment for road-working owned by the county consists of a three-ton roller, which can be increased to a weight of five tons, one road-machine, six mules, wagons, etc. The principal work, so far accomplished by the chain-gang, consists of draining and crowning the roadways, and surfacing the sandy places with clay, together with general repair work.

The rocks suitable for road-material, occurring in Dougherty county, are limestones. These are to be seen, at various places throughout the county, along the streams or about lime-sinks. These limestones are generally comparatively soft, and contain more or less flint, or siliceous matter. A good exposure of these limestones is to be seen, outcropping at the water's edge, where the county-bridge crosses the Flint river at Albany. They are here quite fossiliferous, and contain much flint.

Dougherty county, in the last few years, has constructed three iron bridges, at a total cost of \$30,000, and has greatly improved its highways, by its present system of road-working.

CALHOUN COUNTY

Area, 255 square miles ; approximate road-mileage, 250 ; number of miles of graded road, 0 ; number of miles of macadamized road, 0 ; amount of money annually raised for road purposes, 0. The roads are constructed and maintained by statute labor.

Calhoun county appears to have made but little effort towards the betterment of its highways. The roads are usually sandy, and, in places, in bad condition.

The County Ordinary expresses the opinion, that some other system, besides the one now in use, will soon have to be adopted, or the roads, in places, will become impassable for heavy traffic. Shell limestone suitable for road-surfacing is said to occur in this county in certain localities, in considerable abundance ; but, so far, it has not been used upon the highways.

QUITMAN COUNTY

Area, 168 square miles ; approximate road-mileage, 150 ; number of miles of graded road, 0 ; number of miles of macadamized road, 0 ; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

Quitman county is generally level and the soils are sandy. The road-building materials are quite limited, and of poor quality. They consist chiefly of flint, sandstone, and a siliceous rock containing a high percentage of iron. Clay is found in most localities, for surfacing sandy roads.

RANDOLPH COUNTY

Area, 449 square miles ; approximate road-mileage, 325 ; number of miles of graded road, 0 ; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained chiefly by statute labor.

Randolph county lies within the Tertiary area. Its surface is usually level ; but, in places, it becomes quite broken. Especially is this true, in the neighborhood of the larger streams. The most serious obstacles, in the way of road-construction, are the local beds of sand. Abundance of clay, however, is usually at hand, for the improvement of such sandy places. Last year, all the hands, subject to road-duty, worked on the public roads of this county 15 days ; and, as a consequence, the roads are said to be in good condition. The Ordinary reports, that there has been much interest manifested in road-improvement, in the last two or three years.

The county owns no regular road-working outfit ; but it supplies to each road district one or two drag-scrappers, shovels and picks ; while plows, wagons and teams are hired from the farmers.

The road-building material is mainly limestone. It is of local distribution. A good exposure of this rock is to be seen at Greer's Cove, near Pumpkin Town, in the northern part of the county. The exposure forms a bluff, 25 feet high, along a small stream. The stone occurs in thick, heavy beds. It is usually hard and compact, and is well suited for road-surfacing.

CLAY COUNTY

Area, 192 square miles ; approximate road-mileage, 100 ; number of miles of graded road, 0 ; amount annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

Topographically, Clay county is comparatively level, except in the vicinity of the streams, where the surface becomes somewhat rolling. The roads of the county are usually sandy, and, under the present system, are not always kept in good condition. Each individual subject to road-duty is reported to work, on an average, about eight days per annum, on the public roads of the county. This estimate is much above the average for the State ; and, if the work were faithfully done, the highways should be in fair condition for traffic. Persons subject to road-duty are relieved from work by the payment of 50 cents per day, for every day's work required. In a few instances, this commutation-tax is paid ; but the whole amount, annually collected from this source, is small.

The rocks suitable for road-material in Clay county are limestones. They occur mostly along the streams, where they sometimes form bluffs, 20 feet or more in height. These rocks are to be seen near the mouth of Sandy creek, on the Flint river, five miles north of Fort Gaines. They underlie a belt of country about five miles wide extending in a northeast direction across the county. It is only in places, where the superficial sands and clays have been

removed, that the limestones are exposed at the surface. Lime-sinks and small ponds are characteristic features of this limestone belt. The rock frequently occurs in heavy beds, and is generally compact, and well adapted for road-surfacing.

EARLY COUNTY

Area, 429 square miles; total road-mileage, 400; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for road purposes, 0. The roads are constructed and maintained by statute labor.

The surface of Early county is generally level, and the soils are sandy. The only rock found, suitable for road material, is limestone, which is confined to a few localities.

The roads of the county are worked on an average of about 3 days each year; but the Ordinary reports, that it is contemplated, at an early date, to require each individual subject to road-duty to work four days each year, or pay a commutation-tax of \$2.00. The money derived from this source, he thinks, will aggregate about \$5,000 per year, which will be available for road purposes.

The county, at present, owns no special road-machinery; and apparently it has done but little, in the way of permanent road-improvement.

MILLER COUNTY

Area, 240 square miles; approximate road-mileage, 100; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, 0; number of days worked by road hands each year, 5. The roads are constructed and maintained by statute labor.

Miller county is located in the southwestern part of the State. Its surface is usually low and level, and the soils are sandy. The county is traversed by Spring creek, a stream of considerable size, along which are frequently low, sandy hills and swamp lands. The road materials are limestones and buhrstone, or flint. They

occur mostly along streams. The present system of road-work is reported to be satisfactory. The roads are in fair condition, though often sandy.

DECATUR COUNTY

Area, 1,106 square miles; approximate road-mileage, 500; number of miles of graded road, $\frac{1}{4}$; number of mile of macadamized road, 0. The roads are constructed and maintained by statute labor. Hands work, on an average, five days each year.

Decatur county is located in the extreme southwestern corner of the State. The surface of the country is comparatively level, except in a few places, near the larger streams, where the surface is quite broken. This broken condition of the surface is quite noticeable in the vicinity of Whigham and Fowltown. Sand dunes, or hills, are also sometimes met with, in the more level, piney woods. Such a line of hills is crossed by the wagon-road, a short distance east of Bainbridge, on the way to Whigham. These sands are very light, and the wagon-wheels, in places, sink into them, almost as if they were snow-banks, making the draught exceedingly heavy. The writer recalls a trip over this road, some years ago, when the load had to be lessened at the sandy places, on account of the increased draught, which the team was unable to draw.

The rocks, which occur in Decatur county, suitable for road materials, are limestones and flint. Both varieties of rock are often found together, the flint forming layers or irregular masses in the limestone. They are found in the greatest abundance along the streams or near lime-sinks. The limestone is generally fossiliferous and soft; but it also occurs in a semi-crystalline condition, forming heavy beds. These compact varieties are well exposed beneath the soft limestones, in a small stream near Faceville¹ and also on the Flint river, a short distance south of Bainbridge. Limestone, of similar character, though not so compact,

¹ See fig. 27.

is exposed at the base of Red Bluff, on the Flint river, a few miles north of Bainbridge, and at Forest Falls, near Whigham. The same rock again outcrops at several places along Spring creek. There is quite an exposure of it, on the right bank of this creek, just below where it is crossed by the Savannah, Florida & Western R. R. Besides the limestone and flint, or the so-called buhrstone, there are also a few places in the county, where beds of water-worn gravel and sandstone occur in limited quantities. A good exposure of the sandstone is to be seen on Mr. G. W. Ragan's

Fig. 27



Section through the Gorge along Faceville Branch. 1. Sandy Clays. 2. Partially Decomposed Limestone. 3. Compact, Thick-bedded Limestone.

farm, some eight miles south of Cairo, where an effort was made some years ago to work it into mill-stones. The water-worn pebbles are found chiefly in the vicinity of the sand-dunes between Whigham and Bainbridge. They are always associated with coarse sand, and contain no clay or other material, which would bind them together into a solid road-surface.

Decatur has expended, in the last few years, about \$45,000, in erecting iron bridges. There are three of these bridges in the county. The one across the Flint river at Bainbridge is well constructed, and would be a credit to any county in the State. The Ordinary of the county, in a letter, says, that the highways are kept in a fair condition for travel, and that the system, under which they are maintained, seems to give general satisfaction.

BAKER COUNTY

Area, 355 square miles; approximate road-mileage, 100; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

Baker county lies in the southwestern part of the State. Its surface is level, and the soils are sandy. Rock suitable for road-surfacing is limited. It consist chiefly of limestone, which is exposed mainly along the larger streams. The clays, that can be used for surfacing sandy roads, are widely distributed, and can be usually had at short intervals along all the main thoroughfares throughout the county.

MITCHELL COUNTY

Area, 507 square miles; approximate road-mileage, 500; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

Topographically, Mitchell county is level, and the soils are usually sandy. The road material of the county consists of limestone, which is mostly exposed along the streams. Associated with the limestone, are, frequently to be seen, considerable quantities of flint. This siliceous rock is often highly fossiliferous, and is easily crushed. It is, however, more frequently compact and brittle. In the eastern part of the county, there are said to be considerable deposits of gravel, locally known as pebble or iron-rock. Clays, suitable for surfacing sandy roads, are widely distributed throughout the county.

The public roads of the county are worked, on an average, about five days each year, and are reported to be in fair condition.

THOMAS COUNTY

Area, 784 square miles ; approximate road-mileage, 800 ; number of miles of graded road, 0 ; number of miles of macadamized road, 0 ; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

Thomas county is usually level ; but, in some localities, the surface becomes quite rolling. This is notably true, of the region in the vicinity of Thomasville, where the surface is much broken, and resembles somewhat the more mountainous section of North Georgia.

The road-building material is confined chiefly to the southern portion of the county. It consists of limestone. Good exposures of this rock may be seen on the McIntyre plantation, some eight miles south of Thomasville. It is heavy bedded limestone. Some of the layers are semi-crystalline, and well suited for road-surfacing. Another exposure of a similar limestone occurs on Mrs. Mitchell's farm, seven miles east of Thomasville, near the public road leading to Boston.

The main thoroughfares of Thomas county are, as a general rule, in fair condition ; though, in places, they are sandy. The roads are worked, on an average, about 12 days each year, by the road hands. This time is sufficient to keep the roads in good condition, if the work is faithfully done.

Thomas county has one excellent roadway, the Boulevard, which encircles the city of Thomasville. This is a model earth-road, practically level, and several miles in length. It is the favorite drive of that famous winter resort. A visit to Thomasville can hardly be considered complete, unless a drive is taken on this road. On such a ride, one obtains an excellent idea of typical piney woods scenery. The road is only a common earth road, properly crowned and well drained.

It furnishes an excellent object lesson, of what may be done in the piney-woods section of the State, in the way of constructing good earth roads, at a small expense.

COLQUITT COUNTY

Area, 550 square miles ; approximate road-mileage, 300 ; number of miles of graded road, 0 ; number of miles of macadamized road, 0 ; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor. Hands work, on an average, five days each year.

Colquitt county is generally level, and the roads are sandy. The material for road-surfacing consists of clay and limestone. The latter is found in places, forming considerable beds. It is often quite compact, and well suited for road-metal. Flint, or what is frequently known locally as buhrstone, is also sometimes found in considerable quantities. This stone is usually quite brittle, and possesses but little binding strength. Consequently, it is poorly suited for road-surfacing. Both the limestone and the flint occur chiefly along streams, or about lime-sinks, where they have been exposed by denudation. The clays are often highly colored, and are sometimes spoken of as calico clays. They are mostly siliceous ; and, when mixed with sand, they form a good, compact road-surface.

The roads of Colquitt county are quite similar to those of other counties throughout South Georgia. As far as is reported, there is no desire to change the present system of road-improvement.

BROOKS COUNTY

Area, 529 square miles ; approximate road-mileage, 300 ; number of miles of graded road, 0 ; number of miles of macadamized road, 0 ; amount of money raised, annually, for public-road purposes, 0. The roads are constructed and maintained by statute labor ; and hands work, on an average, five days each year.

During the spring of 1895, the writer, while examining South Georgia for phosphate deposits, had an excellent opportunity, to make a personal examination of some of the leading highways of Brooks county. At that time, the roads were found to be in fair

condition, though, in places, they were a trifle sandy. This defect, however, can be easily remedied, as beds of clay are always near by. Topographically, much of the county is rolling; and, in order to secure first-class roads, a limited amount of grading would be required, in places. Especially is this true of the surface in the neighborhood of the larger streams. The Chairman of the Commission of Roads and Revenues of Brooks county, in speaking of the highways, says: "We have fair roads, and are satisfied with the same."

Exposures of limestone, which would make a suitable material for road-surfacing, occur at several places in the county, about the numerous limesinks and lakes. These limestones are frequently semi-crystalline, as may be seen by outcroppings on the Haddock plantation, a few miles south of Quitman. There are, also, at various localities throughout the northern part of the county, more or less extensive deposits of ferruginous sandstone. It occurs in thin beds in the sands and clays, and is often quite abundant in cultivated fields. At a few places, these sandstone boulders have been used, to a limited extent, in repairing boggy places in the road; but they are too local in their distribution, to become of general use.

LOWNDES COUNTY

Area, 431 square miles; approximate road-mileage, 325; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

Much of the eastern portion of Lowndes county is rolling, and has a clay soil; while the northwestern portion is more level, generally sandy, and often traversed by bay or cypress swamps. Along the State-line, are many small lakes and ponds, occupying limesinks. The largest of these is Ocean Pond, located in the southwestern part of the county near Lake Park. The streams of the county are usually sluggish; and, when swollen in the early spring

by heavy rains, they frequently overflow their banks, and make the approaches to the bridges difficult and often dangerous. The roads of Lowndes county were found to be in fair condition ; but, in places, they are a trifle sandy. They are worked on an average of four days each year. The County Ordinary, in speaking of the present system of road-maintenance, says : "We work under the 'old road law.' It has no merits ; it is failure, pure and simple."

The road material is limestone. It occurs at several places along the banks of the Withlacoochee river, between Old Troupville and the State-line ; also, in the southern part of the county, in the vicinity of the lakes and ponds. It is generally fossiliferous, containing more or less flint, in the form of concretions. Good specimens of the limestone may be seen at Rock Ford bridge, and at the mouth of Jumping Gully creek near the State-line.

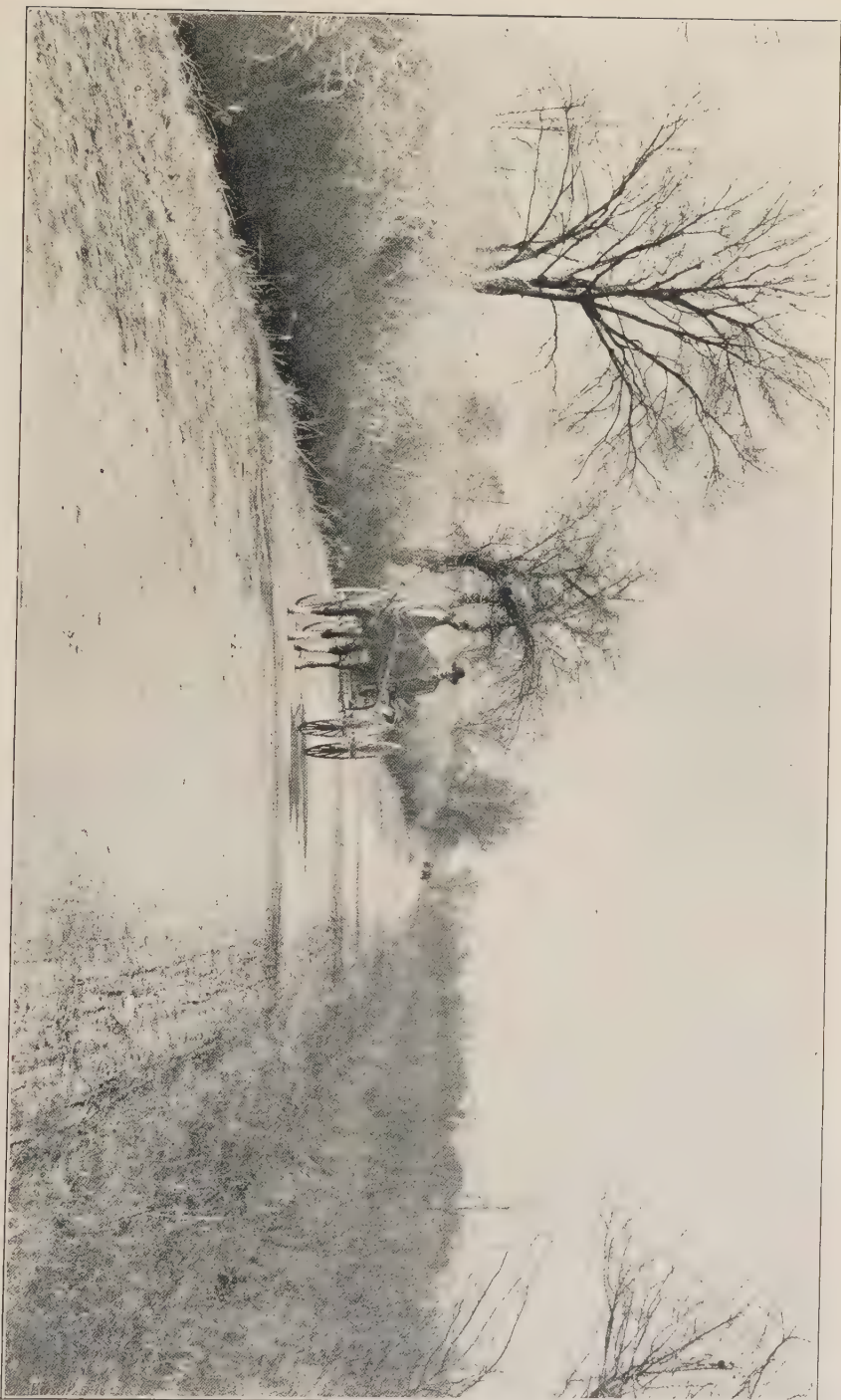
BERRIEN COUNTY

Area, 745 square miles ; approximate road-mileage, 350 ; number of miles of graded road, 0 ; number of miles of macadamized road, 0 ; amount of money annually raised for road purposes, 0. The roads are constructed and maintained by statute labor.

Each individual, subject to road-duty, is reported to work, on an average, six days per year upon the highways. The roads are nearly all more or less sandy, and are reported to be generally in poor condition throughout the county. Rock, suitable for road-surfacing, is limited to a few localities. There seems to have been, so far, but little interest manifested in Berrien county, toward the betterment of its highways.

ECHOLS COUNTY

Area, 390 square miles ; approximate road-mileage, 200 ; number of miles of graded road, 0 ; number of miles of macadamized road, 0 ; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

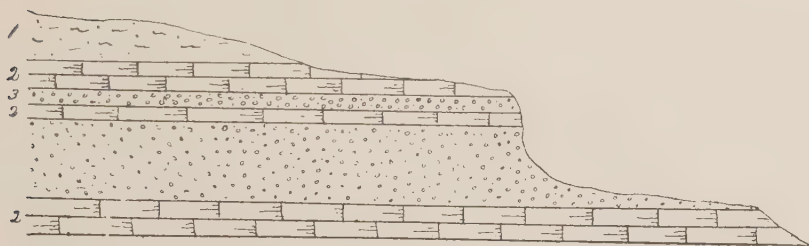


FOSTER'S LANE—A ROAD TO THE RICE-BOTTOM PLANTATIONS, BELOW AUGUSTA, RICHMOND COUNTY, GEORGIA.



Echols county is comparatively level. The lands are often low, and are frequently covered with palmetto and a luxuriant growth of long-leaf pine. Much of the county, especially in the eastern portion, is sparsely settled, and the roadways are often mere trails through the piney woods, made by lumbermen. Swamps and sluggish streams are more or less abundant, forming frequently barriers to travel during the rainy season. The roadways of the county are generally sandy. This is especially true in the vicinity of the larger streams, where the surface is rolling.

Fig. 28



Section through the Rocks on W. T. Green's Property. 1. Sandy Clays.
2. Limestone. 3. Phosphate Pebbles in Calcareous Matrix.

The rocks of Echols county suitable for road-surfacing material are limited chiefly to limestone, although sandstone and flint occur, in small quantities, in a few localities. Some of the best exposures of limestone in the county may be seen along the banks of the Allapaha river, in the vicinity of Statenville, and also along Allapacoochee creek, near the point, where it enters the former stream. There occurs, associated with the limestone, at these places, phosphatic rock.¹ The limestone found in the above localities is compact, and more or less sandy, and weathers into irregular cavities. It often contains nodules of flint, and occasionally, fragments of shells and bones.

Each individual subject to road-duty is reported to work on the

¹ See fig. 28.

highways of Echols county, on an average, about 8 days per year. Under this system, the roads are kept in fair condition for traffic.

CLINCH COUNTY

Area, 988 square miles; approximate road-mileage, 225; number of miles of graded road, 11; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

The roads of Clinch county are under the management of District Road Commissioners appointed by the Ordinary. The District Commissioners, in turn, appoint overseers, who have immediate charge of all hands subject to road-duty. Under this system, each individual works on the highways, on an average, about three days per annum. The roads of the county are generally sandy; and they are frequently in poor condition for traffic. The numerous swamps in the county add materially to the cost and difficulty of road-building. In places, corduroy roads have been constructed by lumbermen; but they are often in such condition, as to be almost impassable. Some time ago, an effort was made, to work convicts upon the public roads of Clinch county; but, after a few months' trial with small chain-gangs, the plan was abandoned.

The only rocks, found in Clinch county, suitable for road-material, are limestone and flint, or buhrstone. These rocks are exposed, mostly in the southern part of the county, along the larger streams. Such deposits may be seen along the banks of the Suwannee river, near the Georgia-Florida State-line.

WARE COUNTY

Area, 893 square miles; approximate road-mileage, 140; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road pur-

poses, not ascertained. The roads are constructed and maintained by statute labor.

The surface of Ware county is quite level, and the soils are generally sandy. Much of the county is swampy. Especially is this true of the southern part. The chief obstacles in the way of road-construction, are the heavy beds of sand and the boggy swamps. The timbermen, in many places, have constructed corduroy roads across the swamps, which, in some instances, are kept in passable condition by the public-road hands, who are reported to work on the roads about 12 days each year.

No rock suitable for road material is known to occur. Clays, however, well adapted for surfacing sandy roads, are more or less abundant.

The county owns one iron bridge, erected at a cost of \$20,000.

PIERCE COUNTY

Area, 555 square miles ; approximate road-mileage, 300 ; number of miles of graded road, 0 ; number of miles of macadamized road, 0 ; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

Pierce county is low and level. The soils are sandy. The roads of the county are kept up entirely by statute labor. The hands are said to work on the highways, on an average of seven days each year. No material suitable for road-construction is reported. The county seems to take but little interest in the betterment of its highways.

CHARLTON COUNTY

Area, 497 square miles ; approximate road-mileage, 140 ; number of miles of graded road, 0 ; number of miles of macadamized road, 0 ; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

The surface of Charlton county is usually level, and presents

rarely but slight variations in topographic features. Okefinokee swamp covers much of the western part of the county; while the eastern portion consists largely of low palmetto lands covered with sand. The great difficulty encountered in constructing hardened roadways in Charlton county is the scarcity of road-surfacing materials. The roads are always sandy; and, in but few places, are clays or other material to be had for surfacing. Limestone outcrops in beds at some points along the banks of the St. Mary's river, in the vicinity of Trader's Hill; but it is poorly suited for road purposes.

Mr. B. F. Scott, Chairman of the Board of County Road Commissioners, in a letter, says: "We work our roads, on an average, about five days each year. Our roads are in a bad condition. The present method is unsatisfactory. We are much behind in highway improvement." Charlton county owns no road-machinery, nor does it raise revenues for road-improvement.

CAMDEN COUNTY

Area, 769 square miles; approximate road-mileage, 300; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, 0; number of days worked by road-hands each year, 5. The roads are constructed and maintained by statute labor.

Camden county is located on the Atlantic coast, in the extreme southeastern part of the State. Its surface is level, and the soils are generally sandy. Swamps are common near the coast, and they often make road-construction expensive. A trip through this county a few years ago by the writer in a wagon, demonstrated the fact, that the public roads were kept in fair condition for common traffic. In places they were often found to be somewhat sandy. However, this defect could have been easily remedied by a coating of clay, which is generally to be had, near by. As far as observed by the writer, the only indurated rock in the county, exposed at the surface, suitable for road-surfacing, was at Burnt Fort

on the Satilla river. The rock is a mud-stone or a clayey limestone, in layers from 3 to 8 inches in thickness. It is too limited in quantity to ever be of much value in road-surfacing. At St. Mary's, and at some other points along the coast, a limited quantity of oyster shells have been used in making hardened ways.

GLYNN COUNTY

Area, 427 square miles; approximate road-mileage, 150; number of miles of graded road, 60; number of miles of shell road, 20; amount of money annually raised for public-road purposes, not given. The roads are constructed and maintained by statute labor.

Glynn county is located on the Atlantic coast in the southeastern part of the State. Its surface is low and level, and swamps are more or less abundant, especially in the vicinity of the coast. These swamps, together with the superficial deposits of sand, so often met with throughout the county, are the chief obstacles to be overcome in road-building. The highways of the county, are generally in fair condition. They are kept up by statute and convict labor. In 1898, according to the annual report of the Prison Commission of Georgia, Glynn county employed, on its roads and public works, 26 convicts. The roads on St. Simons Island are said to be kept up entirely by statute labor, each hand subject to road-duty being required to work on the highways, on an average of about three days each year. Materials in Glynn county, suitable for road-surfacing, with the exception of clays and oyster shells, are almost entirely wanting. Only at one place in the county, has the writer seen rock in sufficient quantity to be of value for road-making. The exposure of rock, here referred to, occurs on the Livingston plantation on College creek, some 10 or 15 miles west of Brunswick. The rock exposed at this place is a compact argillaceous limestone, of a blue color on a freshly broken surface. It occurs along the stream, for a quarter of a mile or more, in thin beds, which readily break up, when exposed to the atmosphere,

into angular blocks, varying from 3 to 8 inches in diameter. A limited amount of this stone, or stone of a similar nature, has been used on one of the streets of Brunswick for macadam ; but, owing to the large size of the fragments, it did not give satisfaction. If this rock were broken into fragments of the proper size, from 1 to 2 inches in diameter, and it were properly put down, there would seem to be no reason, why it would not make a smooth and satisfactory road-bed.

Clays suitable for surfacing sandy roads are widely distributed over the county ; while oyster shells are confined to the coast. The oyster packing-houses in the neighborhood of Brunswick have in the last few years furnished large quantities of shells for road-surfacing. The material, used in surfacing the 20 miles of elegant road-way in the vicinity of Brunswick, was derived from this source. These shell roadways are reported to cost the county only about \$700 per mile. They are remarkably level, and are delightful drive-ways, when kept in repair.

MCINTOSH COUNTY

Area, 419 square miles ; approximate road-mileage, 100 ; number of miles of graded road, 4 ; number of miles of shell road, 4 ; amount of money annually raised for public-road purposes, \$800. The roads are constructed and maintained by statute labor.

McIntosh county is low and level. The soils are usually sandy. Swamps and bogs are numerous, and often seriously interfere with road-building. Mr. J. A. Walker, the Chairman of the Board of County Commissioners, in speaking of the roads of McIntosh county, says : "Our public roads are not very good. We are now working under the superintendency of one man, with overseers under him, when they are necessary." The superintendent is paid a salary of \$600, and has general control of all the roads in the county. All persons, subject to road-duty, are required to work the public roads five days each year, or pay a commutation-tax of

\$1.50. The special road-tax is one mill on the dollar, and this amounts annually to about \$800.

The county has no rock, known to the writer, suitable for road material. Oyster shells have been used, to a limited extent, for this purpose. The roads, so far surfaced with shells, are said to cost about \$1,000 per mile.

LIBERTY COUNTY

Area, 966 square miles; approximate road-mileage, 500; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, 0. The roads are constructed and maintained by statute labor.

Topographically, Liberty county is low and level. It has many extensive swamps, which are serious obstacles to overcome in road-building. In the vicinity of the swamps, the soils are tenacious clays; while, in the more elevated areas, they are usually sandy. During the early history of the State, Liberty county was noted for its excellent roadways. White, in his book, entitled *The Statistics of Georgia*, in speaking of this county, says: "In no part of Georgia, do the citizens pay so much attention to their roads, as in Liberty county." On account of the numerous swamps, there has been an immense amount of labor expended in the construction of bridges and causeways. The bridges are generally small. The writer, during the spring of 1895, travelled over several of the main thoroughfares of Liberty county, and was much surprised, to find the roads in such excellent condition. Especially was this true of the roads in the vicinity of Riceboro, where large sums of money must have formerly been expended, in elevating the surface of the roadways above the general level of the swamps.

The roads of the county are now under the direction of 18 superintendents, one for each road-district. These superintendents receive one dollar per day, for their services, while actually employed on the road, which is usually about six days each year.

Liberty county formerly raised a special road-tax, of $1\frac{1}{2}$ mills on the dollar, for the improvement of its highways; but the tax has not been collected, since 1894. The roads are now kept up entirely by statute labor. Road material is scarce, though some gravel is to be found near the larger streams.

BRYAN COUNTY

Area, 400 square miles; approximate road-mileage, 400; number of miles of graded road, 0; number of miles of macadamized road, 0; amount of money annually raised for public-road purposes, \$600; number of days worked by road-hands each year, 4. The roads are constructed and maintained mainly by statute labor.

Bryan county lies immediately west and south of Chatham. The surface, like that of the adjoining counties, is low and level. The soils, as a general rule, are sandy. Along the streams, swamps of considerable extent occur, which interfere with road-building. The rivers of the larger streams, are often deep and sluggish, and are generally crossed by bridges or ferries. No rock, suitable for road-surfacing, as far as is known to the writer, occurs in the county. The roads are in a fair condition; but, in places, they are sandy.

CHATHAM COUNTY

Area, 433 square miles; approximate road-mileage, 175; number of miles of graded road, 24; number of miles of gravel and macadamized road, 30; amount of money annually expended on the public roads, from \$15,000 to \$50,000. The roads are constructed and maintained by convict and statute labor.

There has been much interest manifested in Chatham county, in the last few years, in the improvement of its highways. In 1896, more than \$50,000 was expended by the county on roads and bridges. The sum now appropriated is much less than the above amount; yet the number of miles of road, yearly improved, is probably greater than in 1896. Many of the leading roads



VIEW ON THE ROAD FROM AUGUSTA TO INMAN'S COMPRESS, RICHMOND COUNTY, GEORGIA, SHOWING A LOAD OF 12 BALES OF COTTON ON AN IMPROVED ROAD, INSTEAD OF 3 BALES, THE NORMAL LOAD ON AN UNIMPROVED ROAD.

radiating from the city of Savannah have been surfaced with gravel, broken stone or shell ; and they are now kept in excellent condition for travel. These surfaced roads, which often extend for several miles into the country, are constructed and maintained by convicts ; while the other roads of the county are kept up by statute labor.

According to the Annual Report of the Prison Commission of Georgia for 1898, Chatham county employs, on its roads and public works, 232 convicts. About a tenth of this number is regularly employed in surfacing and grading the roads ; while the remainder is engaged in ditching, building canals, doing farm-work, etc.

The chain-gang is under the direction of a superintendent and three overseers. The latter are each paid \$75 per month. There are also, regularly employed, 20 guards at salaries of \$45 each per month. The total cost, of working each convict in Chatham county, has been estimated, by Mr. W. F. Chaplin, Superintendent of Public Works and Roads, at 26.1 cents per day. This estimate includes the cost of guarding, and all other expenses connected with the maintenance of the chain-gang.

All the gravel roads of Chatham county are now being constructed of Augusta gravel, which costs, on board cars at Savannah, \$1.15 per cubic yard. In constructing these roads, the surface of the roadway is first leveled and properly crowned, after which the gravel is put in place, to the depth of six or eight inches, and thoroughly rolled, until it becomes hardened. The cost of constructing these gravel roads depends largely upon their width, and the distance, to which the gravel has to be hauled from the railroad. The average cost of an eighteen-foot road, including grading, has been placed at \$3,500 per mile. A limited amount of gravel from Liberty county, and chert from Northwest Georgia, as well as oyster shells, have been used on the roads of Chatham county ; but none of them are said to give as satisfactory results as the Augusta gravel. Besides the gravel and shell roads, the county also has some five miles of macadamized road, con-

structed of granite from South Carolina. This road, which is twenty feet wide, cost about \$5,600 per mile. The road seems to be well constructed; but the large size of the stones in the surface-layer renders it too rough for bicycles, or for pleasure drives. The above estimated cost of road-construction per mile includes several small steel bridges, which have replaced wooden structures across small streams and canals.

The equipage for road-working owned by Chatham county is quite complete, and cost many thousand dollars. It consists of one 10-ton steam-roller, one 4-ton horse-roller, one road-machine, 30 mules, numerous scrapers, carts, wagons, tents etc. This equipage is moved from place to place throughout the county, as the roads are being improved; and, consequently, little time is consumed, in going to and returning from work.

The abundance of sand, the numerous swamps and the entire absence of rock for road-building material renders road-making in Chatham county both difficult and expensive. In many places, the sands are so heavy, that it is practically impossible, for a team to haul anything like a heavy load. In a few localities, clays can be had for surfacing; but all materials for hardened ways must be obtained beyond the limits of the county. The cost of grading roads in Chatham county is reduced to a minimum, by reason of the level condition of the surface. It is no uncommon thing, to see stretches of road extending for long distances with little or no grading. In fact, the surface is so nearly horizontal in places, that drainage is difficult, and the cost of elevating the road-surface above the general level of the plains is frequently considerable.

ACKNOWLEDGMENTS

The Geological Survey is under great obligations to the Chairmen of the Boards of Road Commissioners in some counties, and to the County Ordinaries in others, for special reports on their several counties, from which much of the information included in this chapter was obtained.

—————) (—————



APPENDIX

The following table shows the physical tests on some of the principal road-building materials of Georgia, kindly made, at the request of the State Geologist, by Mr. Logan Waller Page, in the Road Material Laboratory, U. S. Department of Agriculture, Washington, D. C. : —

Specimen No.	Name of Stone	Locality of Stone	County	Coefficient of Wear	Percentage of Wear	Cementing Value
413	Bangor Limestone ..	Blowing Spring.....	Walker	10.6	5.6	74
414	Fort Payne Chert ...	Near Flintstone.....	Walker	1.4	34.7	2
415	Diabase	Near Newnan.....	Coweta.....	17.3	3.1	2
416	Granite	Near Elberton.....	Elbert.....	13.1	3.4	2
417	Knox Dolomite	Ladd Lime Works.....	Bartow.....	5.0	9.8	17
418	Knox Dolomite Chert	Near Lytle (C. of G. Rwy.).....	Walker....	2.5	34.1	9
419	Gneiss	City Canal near Augusta.....	Richmond..	15.7	3.4	8
420	Diabase	Near James Station (C. of G. Rwy.).....	Jones.....	15.2	3.3	6
421	Gneiss	Lithonia	KeKalb	8.3	5.8	2
422	Diorite	Lakewood near Atlanta	Fulton	10.2	5.0	3
423	Granite	Stone Mountain.....	DeKalb	7.5	6.1	13
424	Chickamauga Lime- stone.....	Chickamauga National Park	Catoosa	7.1	6.8	99



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